Sight and Hearing in Childhood

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IN CHILDHOOD

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PREFACE.

"EDUCATION," wrote Paley, "in the most extensive sense of the word, may comprehend every preparation that is made in our youth for the sequel of our lives," and there is a daily accumulating amount of evidence that it may properly comprehend a much larger range of subjects than was ever dreamed of as forming part of the mere "schooling" which represented education to our forefathers. Among other departures from old methods, we are beginning to see the necessity of considering the recipient of teaching, as well as the teaching itself; and to look with some suspicion upon the once orthodox belief that all apt scholars are the results of the skill of the preceptor, and all dunces the exponents of inherited or natural incapacity. Moreover, it has become generally admitted that many children are heavily handicapped in school life by impediments which stand at the very gates of knowledge, but of which the true significance and importance is even now scarcely realised

by the great majority of those whose business it should be to provide compensations for them. The authors, each in his own department, have been forced to realise the heavy toll which is deducted from the possible capacities of the rising generation by defects of sight and hearing, defects which have too often been suffered to pass unnoticed until they were beyond the reach of remedy; and they desire to urge, alike upon parents and upon school managers, that one of the first questions to be asked about a child, in relation either to his school or to his intended calling, is whether he can see and hear with sufficient acuteness to be safely left to take his place among a crowd. It will probably be a surprise to many to learn in how large a proportion of instances the reply would be in the negative. The proportion is so large that, in every case, the inquiry should form an essential preliminary to the work of the teacher, or to the formation of designs for the future of the child.

R. B. C.
A. H. C.

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CHAPTER I.

THE MECHANISM OF VISION.

In order to understand the capacities of the eyes for vision, it is almost obviously necessary to know something of their construction, and of the manner in which their different parts are adapted to the performance of the functions which respectively devolve upon them. It is not my intention in these pages to enter upon any description either of the nature of light, of its refraction, or of the manner of formation of images; but to treat all these questions as matters of common knowledge, and to content myself with saying that an eye, taken singly, and regarded as an optical instrument, bears a close resemblance to a photographic camera, and, like it, is so constructed as to cast upon a screen, situate at a proper distance from its principal refracting media, an inverted image of the external object or objects towards which it is directed. The camera is rectangular, and its screen is a flat surface; while the eye is approximately spherical, and its screen therefore presents a concave surface; but in many respects the analogy between the two is complete, notwithstanding the circumstance that the lens of the camera is exposed to the air, while the lens of the eye is shielded from it by the interposition of a layer of fluid and of a sort of window, the *cornea*, by

both of which some amount of refraction is effected. In consequence of this difference, the rays of light entering a camera fall directly upon its lens; while, in the eye, the lens occupies an interior position, and the rays of light only reach it after passing through the cornea, and through the intervening fluid, which is called the aqueous humour. In the eye, as in the camera, an arrangement is required by which the position or the power of the lens can be so modified as to bring its action into harmony with the distance of the object to which it is directed. Rays of light proceeding from distant objects are parallel or nearly so; and hence they require a smaller amount of bending or "refraction," to unite them at a given distance, than rays proceeding from near objects, which are divergent in proportion to the nearness. Hence, the near object requires either a more powerful lens, or a greater distance between the lens and the screen on which the image is to be cast. In the camera, the lens is provided with a screw by means of which its position relatively to the screen can be changed; in the eye the distance between the lens and the screen is invariable, but there is a mechanism by which the power of the former can be modified to meet the requirements of every distance. The lens of the eye is contained within a transparent elastic capsule, by which it is compressed, and by which the curvatures of its surfaces are flattened, so that it is held at its minimum of refractive power. A muscle within the eye, the ciliary muscle, or muscle of accommodation, is so placed that its contraction relaxes the lens capsule, and suffers the proper lens substance to expand, so that its surfaces become more highly

curved, and their refractive action is correspondingly increased. In a well-formed eye, the distance between the lens and the screen is such that, when the eye is directed towards a distant object, and the ciliary muscle is passive, so that the lens is held at the lowest limit of its refractive power, a clear and distinct image is formed upon the screen. When the eye is turned from the distant object to a nearer one, the image of the latter would be blurred, were it not that the ciliary muscle is at once brought into instinctive and involuntary action. The pressure of the lens capsule is relaxed, and the lens expands and becomes more convex by its own elasticity; the extent of the change being governed by the visual effect. As soon as a clear image is produced, the stimulus to further action of the ciliary muscle ceases; and only the degree of contraction necessary for the maintenance of the result is maintained. As soon as the eye is again turned towards a distant object, the stimulus to ciliary contraction is withdrawn, and the muscle once more becomes relaxed.

A familiar experiment by which the necessity for the lenticular change may be displayed is to look at any suitable object, such as a printed page, through an intervening piece of net, preferably of black net, placed a few inches nearer to the eyes. As long as the eyes are directed to the characters on the page, the threads of the net will be invisible, and their presence will be discernible only as a sort of haze due to the diminution of light. If the observer now looks at the net, so as to see its threads, the printed characters will in their turn become obscure; while, the nearer the net is to the eyes, the more manifest will it become that the clear

view of its threads is not a matter of mere passive receptivity, but is only either gained or maintained by definite muscular effort, which, if continued, would produce fatigue. The practical point to be remembered, in relation to this matter, is that, with well-formed eyes, distant seeing is unattended with effort and is not calculated to occasion fatigue; while near seeing, such as reading, for example, can only be accomplished at the cost of effort, and therefore does occasion fatigue. If the effort be excessive in degree, or if it be unduly continued, the fatigue may be such as to entail practical disability for the work by which it has been occasioned. The effort by which the eye is optically adjusted to meet the requirements of near vision is technically called accommodation; and the power to make this effort diminishes progressively with increasing age. In childhood, the lens of the eye is at its maximum of elasticity, and it expands quickly and freely as soon as the tension of the capsule is relaxed. As life advances, the lens hardens, and therefore expands less readily and less completely, however strenuously the accommodation muscle may strive to set it free. It follows that a child can read small print at a distance of a very few inches from the eye, while an adult can only do so at a greater distance, and an elderly person only at a still greater one. As the required distance increases, the amount of light reflected from the page diminishes as the square of the increase, and hence soon ceases to be sufficient for the requirements of fine vision. It is for this reason that people with normal eyes require spectacles for easy reading at some period between forty and fifty years of age. Their natural lenses are no longer sufficiently elastic to adjust

themselves to the curvatures required for near vision, and require reinforcement by artificial lenses made of glass or pebble, and so placed as to accomplish an adjustment which the eyes have ceased to be able to accomplish for themselves. This is the common lot of mankind, and is not in any proper sense a failure of sight, but only a failure of the power of adjustment or accommodation.

It will be manifest from the foregoing that the normal human eye has no limit to its range of distant vision, except such as may be imposed by conditions of illumination, or by conditions of the intervening atmosphere. It sees the markings on the moon's surface, or the light from a fixed star; and its "far-point" is at infinity. For every eye, on the other hand, there is a definite "near-point" within which distinct vision is impossible, and which recedes farther and farther from the eye as life advances.

Having seen the nature of the optical apparatus by which the visual image is formed, the next point for consideration is the nature of the screen upon which it is received; and herein the difference between the eye and the camera is most conspicuous. In the latter, it is hardly necessary to say, the screen is of ground glass. On this, the image becomes visible for inspection, so that an observer, placed on the side of the screen most remote from the lens, can examine every detail of the image, can magnify these details if necessary, and can finally adjust the distance of the lens before removing the ground glass, and replacing it by the sensitive plate on which the negative is to be impressed by the chemical action of light. In the eye, the screen is a living

membrane composed of nervous tissue, a sort of advanced post of the brain itself, and is in direct nervous connection with some of the centres of activity of which the brain is largely composed. This screen, technically called the retina, lines the concavity of the eyeball for the posterior three-fourths of its extent, and is supported, and kept in place, by a transparent colourless jelly, the vitreous humour, or vitreous body, which fills the cavity behind the lens. To the naked eye, the retina, when detached from its surroundings, has an appearance much like that of a circle of moistened tissue paper; and its thickness ranges from about 0·4 of a millimetre near its centre to about 0·2 of a millimetre at its circumference. The microscope shows it to be composed of several layers, most of which are subservient to the support or nutrition of the essential or perceptive layer, called "Jacob's membrane" after its discoverer, or "the layer of rods and cones" as a description of its structure. This layer lies behind the others over the greater part of its extent; but over a small portion of the centre the others are thinned away, leaving the layer of rods and cones to receive the centre of the optical image, and directly exposed to the incoming light. This thin portion of the retina is called the central depression (*fovea centralis*), and also, from the retinal elements in and immediately around it being faintly tinged with yellow, it is often called "the yellow spot". It is by far the most sensitive part of the retina; and it receives the image of the object situate in the exact point in space to which the eye is directed.

The "rods and cones," of which the perceptive layer of the retina is composed, are the ultimate sentient

elements of the membrane. They differ from each other in the way which their names imply, the rods being tiny cylinders, the cones resembling them anteriorly, but tapering off to points posteriorly. Each rod or cone may be regarded as the termination of a single nerve fibre; and their arrangement and relative positions differ in different portions of the retina. In the human eye, the region of the yellow spot is entirely occupied by cones. In a zone surrounding it, each cone is encircled by a single row of rods; and in parts farther from the centre the circle of rods around each cone becomes double, triple, or even more numerous. The cones are much more sensitive to visual impressions than the rods, and it is believed that they have a monopoly of colour perception. Partly from the greater sensitiveness of the cones, and partly also, perhaps, because the central parts of the perceptive layer are more fully exposed to light, our vision of anything at which we look directly is more clear and vivid than that of anything at which we do not look directly, but the image of which falls on some lateral part of the retina. In figure 1, if A be the object at which the eye B is directed, the image of A will fall upon the centre of the retina at *ys*, and will be seen in every detail. The image of another object, A′, placed laterally to A, and to which, therefore, the eye is not directed, will fall upon a lateral part of the retina, at *y′s′*, and the object will be seen but dimly. The eye will be rendered aware of its presence, but scarcely of its nature, and not at all of its colour; and in order to determine these, must be directed towards it. The actual state of vision, at any moment, has been compared to a picture, of which the

centre is highly finished in every detail, while the outer portions are left sketchy and incomplete. It will be found by experiment that, if the eye be directed to the centre of a line of print at convenient reading distance, not more than a few characters can be seen clearly, and that both ends of the line fade off into grey haze. In the same way, if the eye be fixed upon something in front, and if a brightly coloured object, say a piece of red ribbon, be moved into the field of view from the

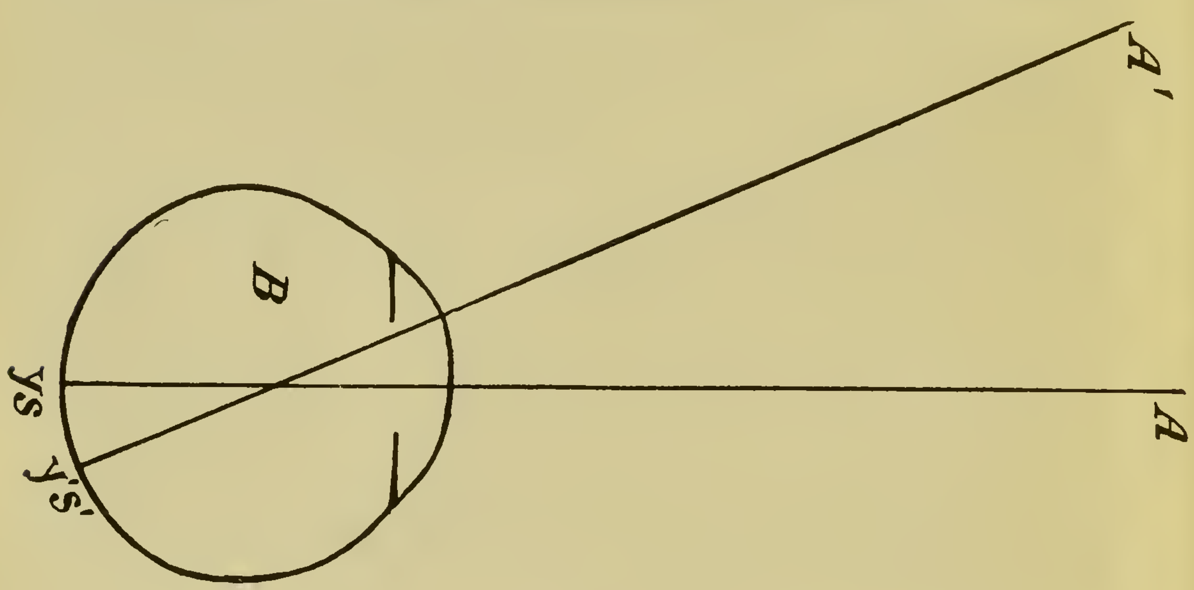

FIG. 1.

outer side, the mere presence of the ribbon will be perceived long before its colour can be recognised.

The imperfection of lateral vision is so completely concealed, in daily life, by the mobility of the eyes, and by the circumstance that every visual impression dwells for an appreciable time upon the consciousness after it has faded from the retina, that only a few people are aware of the conditions, in these respects, under which they live. Many common toys, and all the effects of the cinemetograph, as well as the child's trick of swinging round the end of a glowing stick in order

to produce the appearance of a circle of light, rest upon what has often been incorrectly called the persistence of the retinal image, but which is really the persistence of the impression made upon the consciousness. The absolute retinal image disappears from the eye with the disappearance of the object producing it, just as it would disappear from a camera, and is replaced by that of the object which succeeds it. The impression upon the consciousness, as we shall see hereafter, requires a definite time for its production, and a still longer time for its disappearance.

In these circumstances, an ordinary spectator, gazing at a landscape, may be pardoned for supposing that he sees it all at once. In truth, he can only be correctly said to "see" that portion of it the image of which falls upon the centre of his retina at the moment. The mobility of the eye, ranging unconsciously from point to point of the field of view, the persistence of earlier impressions upon the consciousness, and of still earlier ones upon the memory, combine to blend the vision of the immediate past into a single picture with that of the present; and the mobility of the eye is so instinctive, and so little under the control of the will, that some training and effort are usually required before it can be kept quite still, even for the purpose of experimental observations.

It is probable that the same mobility is largely concerned in producing the ordinary unconsciousness of the very considerable "blind spot" which exists in each eye, and which, at least in historic times, was not discovered until the reign of Charles the Second. At a point a little above the horizontal meridian of each

eye, and on the inner side, the optic nerve enters from the brain, and the extremity of the nerve, which has a diameter of about a millimetre and a half, is totally blind, so that no image falling upon it is perceived by the consciousness. If the left eye be closed, and figure 2 taken in the hand and held horizontally with the dark circle to the right, while the uncovered right eye is steadily directed to the cross on the left, a position will soon be found, by moving the paper a little to and fro —at which the dark circle totally disappears from view. The same experiment may be tried with two shillings upon a table; and Mariotti, the discoverer of the blind

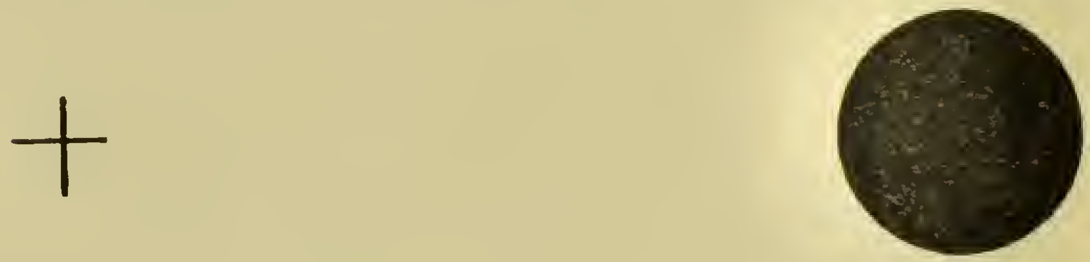

FIG. 2.

spot, was accustomed to illustrate its existence at Whitehall, by placing two courtiers in such relative positions that neither of them could see the head of the other, although they saw each other's bodies distinctly. It is, of course, necessary in such an experiment to close one eye, as otherwise what was lost by the blind spot of one would fall upon a seeing portion of the retina of the other; while the size of the object that can be rendered invisible depends of course upon its distance. At a distance of about a foot, a coin as large as a florin may be made to disappear entirely.

An image formed upon the retina may excite the consciousness in differing degrees, depending upon two

factors, illumination and magnitude. It may be merely "perceived," a term which expresses only a recognition of the presence of some object, or it may be "seen," a term which expresses a visual (as distinguished from a mental) recognition of the nature of the object. A sportsman in the Highlands may perceive certain moving objects on the side of a distant hill; and would probably say at once that they were deer, and that he "saw" them. In truth, all that he does is to "perceive" moving objects, and he forms an opinion that they are deer, an opinion which is formed on quite other data than those of vision, and which may conceivably be erroneous. If it be correct, and if he put up a telescope, he will really "see" that the objects are deer; that is to say, he will obtain a visual image better illuminated and of greater magnitude, by which error is rendered impossible. He will "see" whether the moving objects are deer or something else. I purpose in the sequel to limit myself to such use of the verb "to see" as may express a clear visual recognition of the nature of the thing looked at. Everything short of this is more properly called "perception".

The degree of illumination required for "seeing" is conditioned by the sensitiveness of the cones, and the degree of magnitude is conditioned by their diameter. This is too small to be expressed in words which will convey meaning to any but practical microscopists, and, at the thickest part of the cone, is about 0·002 of a millimetre, so that about 12,500 cones would lie side by side in a linear inch. The total number of cones in an adult human eye has been estimated at about 7,000,000, of which some 13,000 are included within

the central area of acute vision, and the rest are distributed among about 130,000,000 rods. Each cone, taken independently, would have a circular transverse section; but when closely packed together in the eye they are necessarily rendered hexagonal in outline, so that each one may lie in contact with the surrounding cones at every point; and the surface on which the visual image is received may therefore be described as a mosaic of hexagons. The individual hexagons of this mosaic react as units to luminous impressions, and are unable to analyse the sensations which they transmit.

Fig. 3.

The meaning of the statement that each hexagon reacts as a unit, and is unable to analyse impressions, may best be illustrated by a figure. Let it be supposed that the eye is directed to a black circle painted upon a white surface; the effect of which will be to produce upon the retina a corresponding image. Let it further be supposed that the black circle is of such a size, and at such a distance, that its retinal image is smaller than the surface of a single sentient element, and is completely contained within its boundaries, as in figure 3. The affected element, as shown by the hexagon, would in that case receive less light than the hexagons

surrounding it; and the resulting difference, if sufficient in degree, would impress the consciousness with the fact that there was a dark spot in the field of vision. It would do no more than this. There would be no power of judging whether the image of the dark circle fell upon the centre of the hexagon or upon its upper or lower portion; the hexagon would respond as a whole to the fact that it was receiving less light than its neighbours. The spot might be rendered less conspicuous by being reduced in size, or by the substitution of grey for black in its colouring; and it may be assumed that for every eye there would be a point, either of minuteness of the black image or of diminished saturation of the grey one, at which consciousness of the presence of the dark object would cease. The hexagon receiving its image would no longer be sufficiently affected by the diminished illumination to become aware of it. Here, therefore, the sensitiveness of the retina comes into play; and affords scope for differences between individuals, or between the powers of the same eye at different times and under different conditions.

The size of the retinal image of any object depends upon the visual angle under which the object is seen; that is to say, upon the angle formed between lines drawn from the boundaries of the object, and crossing one another at a point within the eye known as its optical centre; lines corresponding with the paths taken by rays of light which are proceeding to form an inverted image upon the retina. The magnitude of the visual angle is determined partly by the size of the object and partly by its distance. If AB, figure 4, be the object, and C the crossing point within the eye,

ACB will be the visual angle, and the corresponding and equal angle *aCb* will obviously determine the size of the retinal image. If the object AB be brought nearer, as at A′B′, it will be seen under the larger angles A′CB′ and *a′Cb′*; and if an object DE, only half the size of AB, be brought within only half the distance of AB from the eye, it will be seen under the same angles as the former. It follows that the opinion we

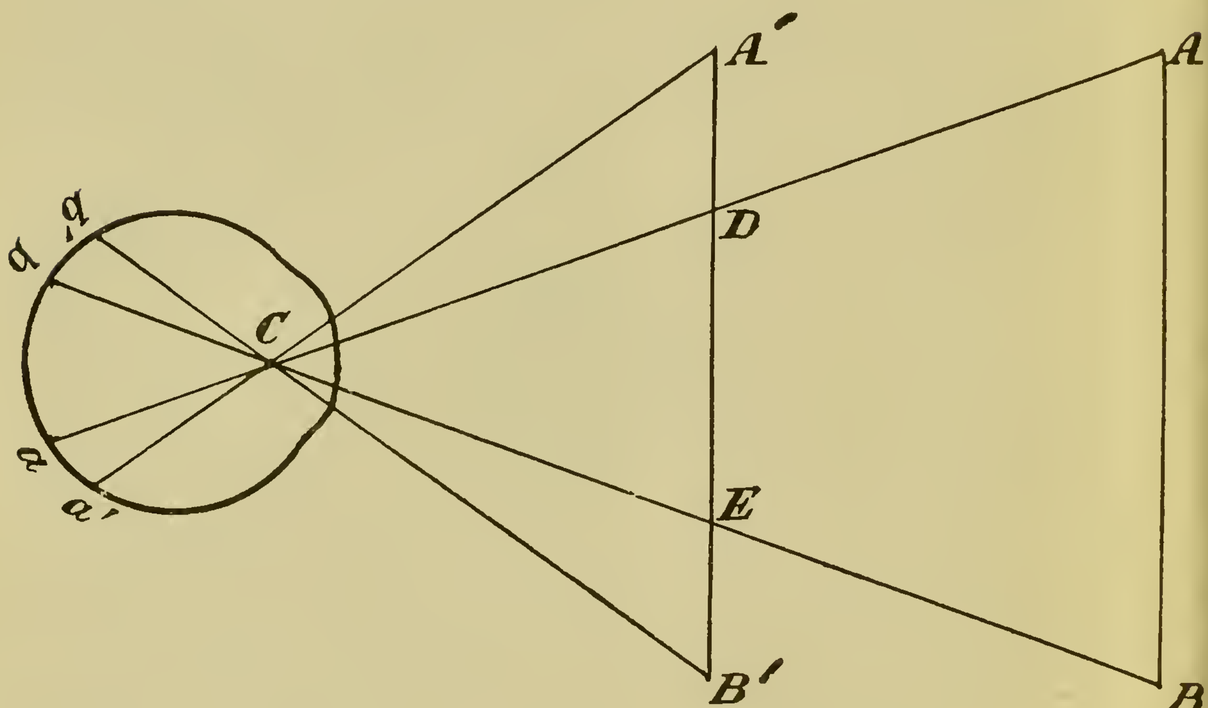

Fig. 4.

form of the size of an object of vision rests partly upon the size of the retinal image, and partly upon our judgment of the distance of the object which produces it. It would be quite possible, for example, to have close at hand, on a table, a model of a house which should afford a retinal image of the precise magnitude of that afforded by the house itself, as seen from the same point as part of a landscape. The spectator would

nevertheless have no difficulty in believing the house to be larger than the model, because intervening objects would show the former to be the more remote. Still, this estimation of magnitude is not a matter of sight but of judgment; and the art of pictorial representation affords many illustrations of methods by which the judgment may be deceived.

Although the size of the retinal image, taken alone, affords no criterion of the size of the object, it nevertheless determines, for each individual, the degree of acuteness of vision which it is possible for him to attain.

Fig. 5.

Seeing, as distinct from mere perception, manifestly requires the visual recognition of the separate parts of which any visual object is composed, as, for example, of the several lines entering into the formation of printed letters. This recognition is only possible when the retinal image is of sufficient magnitude to leave an unaffected hexagon, or more than one, between the images produced by neighbouring but separate parts. Figure 5 represents the hexagons of the retinal mosaic, receiving two images of the same letter E, a larger and a smaller one; the latter such as would be produced by removing the letter itself to a greater distance. In the larger, it will be seen

that there are absolutely unaffected hexagons between the upper and middle horizontal lines of the letter, and again between the middle and the lower; and that the length of the upper and lower lines of the image exceeds by more than a hexagon the length of the middle one. The eye, in such conditions, would recognise both the separateness of the three lines and the shortness of the middle one, and would see the shape and formation of the letter. With the smaller E, on the other hand, these conditions are not fulfilled. The hexagons between the upper and middle line, and the hexagons between the middle and the lower line, are alike encroached upon by the images of these lines, and would be visually affected by them; while the difference in length is also less than a hexagon. The intervals between the lines and the difference in length would in these conditions alike cease to be visible, and the different parts of the letter would be confounded together in a single blur. The same conditions are well exhibited by the stars, all of which, with perhaps the one exception of ε Lyræ, appear to the unaided eye as single points of light. A very moderate telescope reveals the fact that vast numbers of them are double; and it does this by simply so enlarging the image of the interval between the two stars that it leaves an untouched hexagon, or more than one, between the images of the stars themselves. In ε Lyræ, which, on a clear night, and with good vision, can just be discerned as a double by the unaided eye, a telescope shows each of its two components to be double, so that it is really a pair of doubles. As a real test of the acuteness of vision, although printed letters are convenient and useful, there

is nothing so completely accurate as the arrangement contrived by Burchardt, and of which an example is shown in figure 6. It consists of a group of circles or dots, each of which is separated from its neighbour on either side by an interval precisely equal to its own diameter; and the test is afforded by the measurement of the greatest distance at which it is possible to count the dots with certainty. As soon as this distance is exceeded, as soon, that is, as the images of the intervals cease to be large enough to cover a complete retinal hexagon, it is no longer possible to count the con-

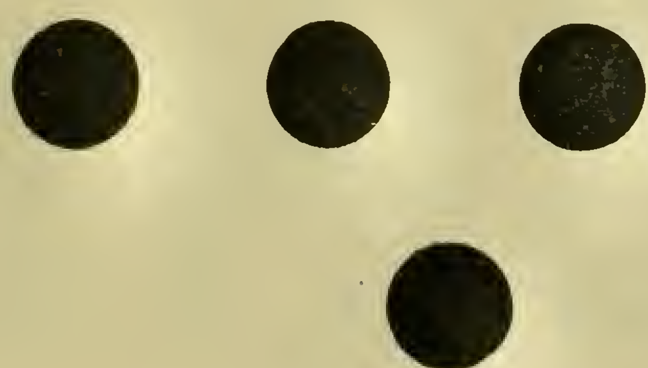

FIG. 6.

stituents of the group, which then assumes the appearance of an irregular line. The separateness of the dots in the figure, or the identity of the letters in Fig. 7, should be recognised, in a good light, at a distance of about 55 feet.

For most common purposes, however, the acuteness of vision is tested by letters or types of symmetrical proportions and of graduated sizes, of which the best-known series is that which was designed by Professor Snellen, of Utrecht. They are based upon the assumption that a healthy eye will distinguish the shapes of letters which subtend a visual angle of five minutes,

and of which the separate parts or limbs subtend a visual angle of one minute. Such letters are shown in figure 7, and it will be seen by the faint lines that the width of their individual parts is just one-fifth of the height of each letter as a whole. They are made in successive sizes, each of which subtends the needful angles when placed at a distance of some specified number of feet or metres from the seeing eye ; and the smallest distance at which the rays of light proceeding from the letters may be regarded as practically parallel is twenty feet, which is therefore taken as a convenient

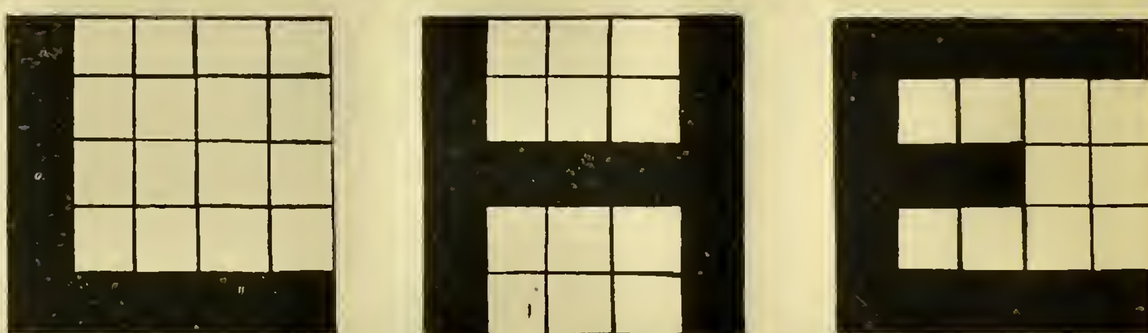

FIG. 7.

distance for testing. The acuteness of vision is expressed by a fraction, which has the actual distance of the letters for its numerator, and the number of feet or metres at which the letters actually read should be legible as its denominator. Suppose the series to descend from letters large enough to be read at eighty feet, through those which ought to be read at sixty, forty, and thirty, to those which ought to be read at twenty ; and that the person tested is twenty feet away. If he can read the smallest size, the twenty feet letters, he has vision equal to 20/20ths, or one, and this is accepted as the standard. If he can only read the forty feet letters, he has vision equal to 20/40ths, or one half ; and if he can

only read the eighty feet letters, he has vision equal to 20/80ths, or one-fourth. Sheets of these graduated test-types may be obtained from any optician, and they ought to form part of the furniture of every nursery and school-room. They are in regular use in the public services, and candidates are accepted or rejected by their means. In the Royal Navy, for example, complete vision, or 20/20ths, is required from each eye, and no glasses are permitted. In the Army, 20/80ths, or one-fourth of proper vision, is required from each eye unaided; and only candidates who possess this are permitted to use glasses. From those who do, it is required that the assisted vision of one eye should be 20/20ths, and that of the other at least 20/40ths.

The general principle, that an interval between any two parts of an object can only be seen so long as its image on the retina is large enough completely to cover one or more hexagons, affords an explanation of the practical invisibility, at moderate distances, of such apparently conspicuous animals as tigers or zebras. As soon as a zebra is so far away that the image of the width of a white stripe is no longer broad enough to fulfil the indicated condition, that white stripe blends with the neighbouring black ones into a uniform grey; and, as many African sportsmen have borne witness, a distant herd of zebras forms a mere grey patch on the veldt. On the same principle, and for the same reason, a tiger is difficult to see in an Indian jungle. His light and dark stripes soon cease to be distinguishable; and his general colour blends easily with that of dead leaves or of vegetation.

Precisely as the power of perceiving the presence of

an object of small size or faint illumination is governed by the sensitiveness of the retinal elements, so that what is visible to one eye may be invisible to another; so the power of definitely seeing the characteristics of a small object is governed by the actual magnitude of these elements, and in this respect it is quite possible that there may be important differences between different individuals and different races of men. It is manifest that such objects as Burchardt's dots would be distinguished apart at distances proportionate to the actual diameters of the cones of the seeing eye, and increasing as these diameters diminished. It is practically impossible to bring this conclusion to the test of actual observation, by microscopic measurements of the cones of different eyes, because the retina rapidly undergoes *post-mortem* changes which profoundly alter its structure, and because the necessary skill in the preparation of microscopic specimens, and in the interpretation of microscopic appearances, is by no means widely distributed. But evolution teaches us that all the varied forms of eye which are met with throughout animated nature, and which have been modified by natural selection in ways determined by the needs or habits of their several proprietors, have been developed from an extremely simple type, probably even from that mere sensitiveness of the anterior extremity to light, which Darwin found to exist in earthworms. A remarkable difference has been brought about, by this development, between the eyes of mankind and those of many birds, in which the cones are less collected together centrally than in man, and are more generally distributed over the whole retinal surface, besides being furnished with

internal coloured globules, which are supposed to minister to a high acuteness of the colour sense. A brief observation of poultry in the act of feeding will suffice to show that, with them, lateral vision is much more acute than in mankind. A hen picking up barley, and with her eyes apparently fixed on the point of her beak, may constantly be seen to make a lateral dash after some outlying grain, the very presence of which, in like relative positions, would be invisible to a human eye; and it is obvious that the lateral acuteness both of form and of colour sense, presumably given by the distribution and the special character of the cones, would greatly facilitate the conduct of such proceedings. I am inclined to think, on the basis of what we know of the functions of the sense organs in general, that the sensitiveness of the nerve elements of the human eye would admit of considerable increase by training, in the case of almost every individual, and that the continued exercise of acuteness of vision might not improbably lead to structural improvements in the race; to such improvements, for example, as an increased fineness and consequently increased number of the cones, and possibly to their more extended distribution over retinal areas which at present are but imperfectly provided with them. Of the increased practical utility which may be conferred upon ordinary eyes by diligent exercise there is, I think, no doubt whatever.

It has very commonly been said by travellers, but probably on insufficient grounds, that the individuals of many savage or semi-savage races possess a distinctly greater acuteness of vision than the majority of civilised men. Arago declared that he met a Tartar in Siberia

who had never looked through a telescope, but who was acquainted with Jupiter's third satellite, and had witnessed its occultation. The man said that he had seen the big star swallow a little one, and spit it out again. Humboldt mentions an occasion on which, in South America, he had divided his party on account of a scarcity of water, and went with half of them along one side of a wide valley, while the rest went upon the other. On the journey, he expressed to his Indian guide some curiosity about the whereabouts of the others, and the guide, pointing across the valley, said "There they are". Humboldt could not see them, even when the guide told him where to look, but he had recourse to his telescope, and, having found the party, further tested the guide's vision by making him describe the order of the march, which he did with complete accuracy. A few isolated examples of this kind, however well authenticated, would be insufficient to establish any general rule; and Professor Huxley was probably correct in the opinion which he expressed in 1890, in a letter which is quoted in his *Life* (vol. ii., p. 268): "Inferiority of senses in Europeans is, I believe, a pure delusion. Professor Marsh told me of feats of American trappers equal to any savage doings. It is a question of attention. Consider wool-sorters, tea-tasters, shepherds who know every sheep personally," etc., etc.

On the whole, I think we must admit the possibility, or even the probability, that some persons are more highly endowed, in respect of vision, than others, alike from the possession of finer and more numerous cones, and by reason of a greater sensitiveness to the impressions which these cones receive; but I greatly doubt

whether these natural differences, supposing them to exist, are peculiar to any race or races of mankind, or are at all equal in amount to the differences which may be developed by practice and training. In respect of form vision, by which, in the main, we recognise the nature of an object, practice is all-important. A sheet of test-types, at a distance at which every letter would be legible to a normal eye, would present only a sheet of blurs to a short-sighted one; but the short-sighted eye, by constant practice, by going near enough to recognise a letter, and then by receding to study the character of its blur, will in time learn to distinguish some of these blurs from those adjacent to them, and thus to name letters which would at first have been wholly undistinguishable from one another. The practised eye learns to recognise the meaning of slight indications which are unnoticed by the unpractised one, and learns also, I think, to distinguish between smaller retinal images than the unpractised one. It becomes, generally speaking, more sensitive to impressions. A town child, transported into a country lane, might see something moving in a hedgerow when a country child, habituated to such appearances and accustomed to observe them, would see that the moving object was a bird, or a mouse, or a snake, as the case might be. If the two children were hunting for wild strawberries, or for birds' nests, the country child would find twice as many as the other. He would not only know better where to look and what appearances to look for, but he would recognise the nature of the images more quickly when they were actually received upon his retina. A large part of his superiority, moreover, would

be due to the more constant exercise, and consequently to the more effectual training, of his power of distinguishing slight differences in colour.

It will probably be conceded that, as a natural consequence of the greater and more varied employment of colour in female dress than in that of males, girls are from their earliest years more accustomed to note differences of colour than boys; and it is certainly true that what is properly called colour-blindness, that is to say, an inability to perceive one of the three principal colours of the spectrum, is almost precisely ten times more frequent in boys than in girls. How far the two conditions may be related as cause and effect we have scarcely sufficient evidence to say; and it must not be forgotten, as an element in the question, that real colour blindness appears to be absolutely incurable, and not to admit of the smallest alleviation either by practice or any other means. The power of recognising some particular colour, either in its simple form or as a modifying element in others, is absent, and cannot be acquired. But it is no less true that, given the possession of normal colour sense, the power of recognising minute differences admits of cultivation in a very high degree, and of course implies a similar power of recognising and distinguishing the diverse objects by which such minute differences are presented to the eye. An average rustic would see very little difference between the blue of a gentianella and that of a corn flower, or between the blue of the sky and that of a veronica, while the colour expert, the dyer or the silk merchant, would have names for a score of intermediate shades and tints, and would be in no danger of falling into the smallest error

or confusion with regard to any one of them. The difference is analogous to that between a trained and an untrained ear for music; the former able to recognise little more than the general effect of a volume of sound, the latter able to follow any single instrument through all the complications of an orchestral performance. In the same way, a trained eye will recognise a hare sitting in her form, or the presence of any other natural object mimetic of its surroundings, at times and in conditions in which the untrained would see nothing more than an apparent uniformity of surface. I was lately consulted about the case of a young military officer, whose visual examination had been carelessly conducted when he was accepted, and who was perfectly colour-blind. He was going to South Africa, and I had to caution him that at fifty yards or so he would be unable to see a man in khaki lying upon green grass. It is obvious that a highly cultivated colour sense would render it comparatively easy to see the man in khaki, even through small interstices between green leaves behind which he was concealed. The trained scout would stand at the other end of the visual scale from the colour-blind officer.

It follows from what has been said that the possession of normal vision implies the possession of an eyeball of normal shape and proportions, and of retinal terminals (rods and cones) of normal fineness of structure and of normal sensitiveness to impressions, both of light and of colour. It implies also a normal rapidity of reaction on the part of the general nervous system; and it is at least probable, nay is almost certain, that both the sensitiveness and the rapidity of perception

and reaction admit of a high degree of cultivation by practice.

Such being the conditions of sight with regard to one eye singly, they are to some extent complicated by the combination of the two eyes as a pair; that is to say, by the need for binocular as well as for monocular vision. The combination of the two eyes affords certain special advantages; first, a larger lateral field of indirect vision; secondly, the power of promptly distinguishing between flat and projecting surfaces; thirdly, the power of sustaining prolonged watchfulness without fatigue, for which purpose the two eyes are believed to relieve each other, and to be, so to speak, active and passive by turns.

The field of vision of each eye, on the nasal side, is manifestly restricted by the projection of the nose, and extends, as a rule, over about 145 deg. in the horizontal meridian; 55 inward from the point of fixation, and 90 outward. The horizontal extent for the two eyes must manifestly be 180 deg., and it is plain that the increase from 145 to 180 must be of great importance as a source of knowledge of our position and relations in space. A single trial will show that if, when looking directly forward, we close one eye, we lose consciousness of the presence of many objects on that side which were previously within the field of indirect vision. We give ourselves, artificially, a "blind side".

In order that vision with the two eyes may be helpful, it must be single vision, and the condition of singleness is that the visual image is received upon corresponding portions of the two retinæ. The term "axis of vision" is used to express an imaginary line extending from the object looked at to the centre of the

yellow spot. In figure 8 A is the object looked at, and AR and AL are respectively the axes of vision of the right eye and of the left. Both images, the image seen by the eye R, and the image seen by the eye L, are received upon the yellow spot, and the object is seen singly. The image of a second object to the left, at B, seen indirectly, falls to the right of the yellow spot in both eyes, and at a corresponding distance from the

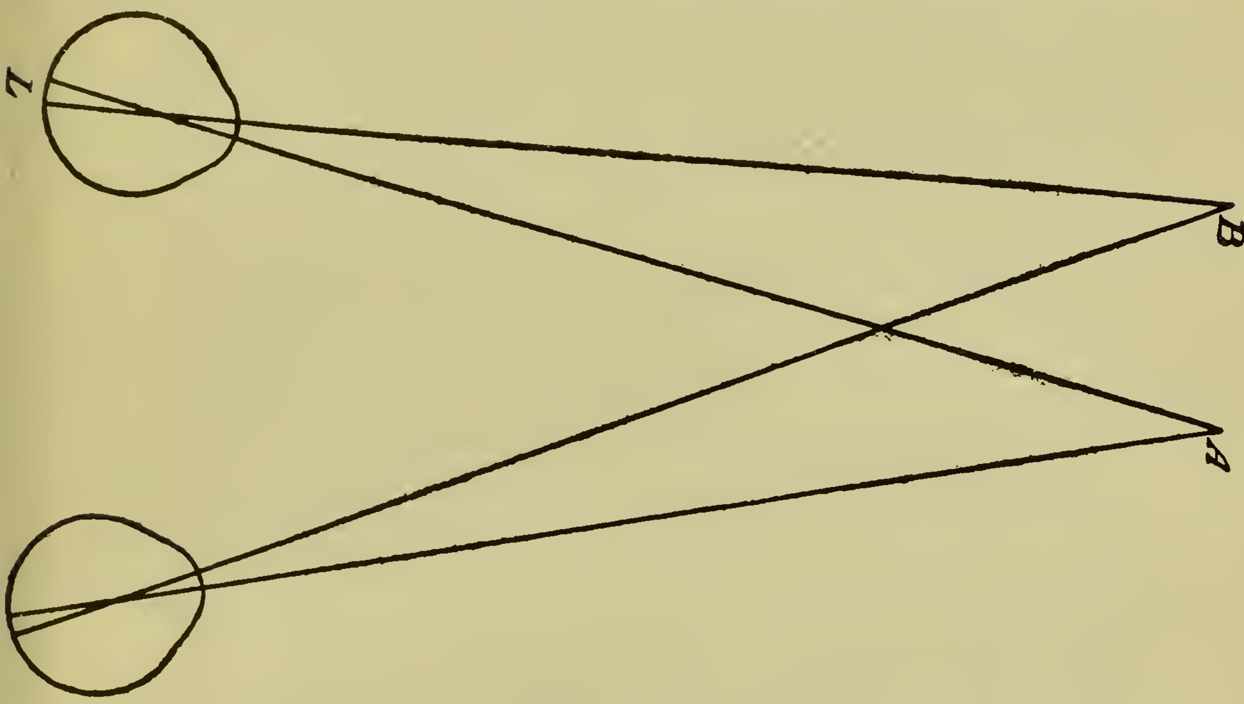

FIG. 8.

centre in both, and this object, like that at A, is seen singly. If either eye be pushed with a finger the least bit out of its normal position in relation to the other, both A and B are at once seen double, because their images no longer fall upon corresponding portions of the two retinæ. The necessary movements are impressed upon the eyeballs by muscles, called from their respective positions the external, internal, superior and inferior straight muscles of the eyes, aided by two

others, the superior and inferior oblique. The external straight muscles, acting together, render the axis of vision parallel, and adjust the position of the eyes for receiving on corresponding spots the images of distant objects; while the internal muscles, acting together, render the axes of vision convergent, and adjust the position of the eyes for receiving on corresponding spots the images of near objects; the degree or amount of convergence necessarily increasing in proportion as the object is brought nearer. The right external and left internal muscles, acting together, turn both eyes towards the right; and the left external and right internal muscles, acting together, turn both eyes towards the left. The functions of the oblique muscles are more complicated, and hardly call for explanation in a treatise of this description; but it may be said generally that the business of the whole number, considered as a group, is to move the eyes from point to point over the whole of the field of vision; and, in every possible direction of the gaze, to maintain such a relative position that every image formed by any external object is received upon corresponding points of the two retinæ, and hence conveys only a single impression to the consciousness.

The amount of effort exerted by the muscles of the two eyes, in order to bring them both to bear in a proper manner upon any given object of vision, is appreciated by means of the endowment known as "muscular sense," by which we not only feel the amount of effort we are exerting for any purpose, but are guided in apportioning that effort to the amount of the anticipated resistance. It is by the "muscular sense," so employed, that we are able to form a just notion of the distance of

an object of vision, and hence, as already explained, to derive from that notion, when combined with the size of the retinal image, a notion of the size of the object itself. In the illustration already given, of a house and its model, producing equal retinal images, the spectator would feel that, for the near model, the muscles of the eyes were exerting an appreciable convergence effort, while, for the distant house, the visual axes would be approximately parallel; and he would judge of their respective distances accordingly.

It will be obvious, on reflection, that the circumstance which calls for the convergence of the two eyes as a condition of single vision, that is to say, the nearness of the object to which they are directed, calls also for a corresponding effort of the accommodation, by which a near object is made to afford clear retinal images. It follows that the fatigue liable to be produced by continued application of the eyes to near objects may be first and most severely felt in the accommodation muscles, or first and most severely in the convergence muscles, or equally in both. The two functions, accommodation and convergence, are not only constantly called into combined activity by the events of life, but their motor centres are closely associated in the brain; and, in most people, there is no power of separating them in action. It is usually impossible to accommodate for near vision without accompanying convergence of the eyes towards a near point, or to converge towards a near point without simultaneous accommodation for near vision. We shall see hereafter that the conditions of visual effort hence arising have in many circumstances a very important practical bearing upon the use and the endurance of the eyes.

CHAPTER II.

CAUSES OF DEFECTIVE VISION.

Without entering at all into the question of any changes brought about by disease, which it would be foreign to the object of these pages to discuss, the conditions essential to perfect or normal vision may be departed from in a variety of ways, as consequences of departure from the natural shape and proportions of the eye, or of absence or imperfection of the natural endowments of some of its parts. A well-formed or normal eye has already been described as one in which the focal length of the crystalline lens when at rest, and the axial length of the portion of the eyeball posterior to the lens, are equal to one another, so that a clear and defined image of distant objects is thrown upon the retina. Between these two magnitudes, the focal length of the lens and the axial length of the eyeball, there is no necessary connection ; and it is manifest that either of them may be either greater or less than is usual. If we assume that the focal length of the lens is invariable, it is manifest that the eye itself may be either too long or too short, that it may depart from sphericity either by being ellipsoid or oblate. If the eye be too long, that is to say, if the distance of the lens from the retina be greater than the principal focal length of the former, the rays of light passing through the lens will be brought

to a focus before they reach the retina, will overcross and become divergent again by the time they reach it, and will imprint upon it, not a clear image, but a blur or dispersion circle, the indistinctness of which, or its departure from the conditions necessary to afford a clear image, will be precisely proportionate to the amount of the difference between the two magnitudes concerned. A person in this condition has no clear vision of distant objects, and cannot attain to such vision by any effort of his own, but he may see near objects perfectly, and is said to be "short-sighted," or "myopic". The parallel rays falling upon his eye from distant objects are brought to a focus before they reach his retina; but the rays from near objects are divergent when they reach the eye, and hence require a longer course than parallel ones before they can be united by the same degree of refractive power. For every degree of elongation of the eyeball, there is an amount of approximation of the object just sufficient to allow the lens to bring these divergent rays to a focus in the right place, that is to say, upon the retina, and this degree of approximation indicates the "far-point" of the eye in question. For example, if the eye be a millimetre too long, the far-point will be thirteen inches away. The eye will be able to read small print easily at thirteen inches, but will not see clearly at any greater distance. If the eye were three millimetres too long, the far-point would be about five inches. The smallest print might be read at this distance, but the general objects in a room would be only dimly discernible.

Short-sight, when present in only a moderate degree, and in an eye in other respects healthy, may be com-

pletely corrected by concave spectacles, which render the parallel rays divergent in their passage through them, and hence enable them to be brought to a focus upon the retina. In the first case supposed, it would be necessary to use a lens of sufficient power to render parallel rays as much divergent as if they proceeded from a point situate thirteen inches in front of it. Thus provided, the eye would obtain clear vision to the horizon. In the higher degrees of short-sight the correction, for various reasons, is less effective, and it is but seldom that, with any help, the standard of normal vision can be reached.

If we take the opposite condition, that of an eye which is, say, one millimetre too short, or too flat from front to back, parallel rays of light passing through its lens would reach the retina before they were united instead of afterwards, and would produce upon it a blur or dispersion circle instead of an image, a blur differing from that of short-sight merely in being produced before the union of the rays instead of afterwards by their overcrossing. But the flat eye, technically described as "hypermetropic," differs from the short-sighted eye in the very important way that it is able, within certain limits and during early life, to correct its own defect. The instinctive desire for clear images compels it, when looking at distant objects, to call into activity that function of "accommodation" which the normal eye only requires when looking at near objects. The internal lens is rendered more convex by muscular action, in the manner already described, and its increased refractive power then enables it to unite parallel rays upon its retina. If called upon to look at near objects, it is

compelled, of course, to make a similar effort in a still greater degree; and hence the general difference between a normal eye and a flat one is that the former is passive or at rest when looking at distant objects, and is only called upon for effort when looking at near ones, while the latter is never passive during waking hours. It is called upon for a sustained effort even when looking at a distant landscape, and for an effort still greater as soon as its gaze is directed to any near point.

About the year 1790, Dr. Thomas Young, physician to St. George's Hospital, the first decipherer of Egyptian hieroglyphics, and the originator of the undulatory theory of light, was struck by the circumstance that the far point of his own short-sighted eyes was less remote for horizontal lines than for vertical ones; or, in other words, that he was more short-sighted for the former than for the latter. He was able to see vertical lines clearly at ten inches, but horizontal ones not until they came within seven inches. He at once perceived that this condition must be due to a want of symmetry either of the corneal surface or of that of the lens; that is to say, to a sharper curvature in one of the meridians of the eye than in another at right angles to the first; and, having calculated the precise difference between the two, he corrected this difference by a cylindrical lens which was ground to his order for the purpose. More than fifty years afterwards, the same history was repeated by the then Astronomer Royal, Sir George Airy, and the condition which he described as existing in himself received from Professor Whewell the not very felicitous name of "astigmatism". It does not seem to have occurred, either to Young or to Airy, that

such a want of symmetry might be common; and this discovery was reserved for Professor Donders of Utrecht, who, about 1860, published a treatise on astigmatism, explaining how its various degrees and forms might be estimated, and how glasses might be employed to correct them. It has since been rendered apparent that a small degree of astigmatism, discoverable by delicate tests, although insufficient to produce any marked effect upon ordinary vision, is rather the rule than the exception in the human eye; and, in 1892, as the result of an examination of my own case-books, I found that astigmatism had been present, in a degree to require correction, in the eyes of 1,400 private patients out of the last 10,000 by whom I had been consulted. All that need here be said about it is that astigmatism is found in combination with both short-sight and flat eye, and that it adds, in some degree, to the difficulties attendant upon either.

The foregoing conditions of faulty shape or defective symmetry of the eyeball are calculated to impair vision by diminishing the perfection of the image formed upon the retina; but we are also liable, though less frequently, to meet with cases in which, on account of some defect in the nervous apparatus itself, either in the retina, in the conducting fibres which constitute the optic nerve, or in the chief visual centres in the brain itself, the retinal image, however well formed, fails adequately to stimulate the consciousness. Hence we sometimes find in children one eye with normal sight or nearly so, while the other is highly defective; and occasionally, but much more rarely, we find both defective, without there being anything in the history of the individual, or in the

appearance of the eyes themselves, either externally or when examined internally by the ophthalmoscope, to explain the cause or nature of the defect. Such cases must be distinguished from those in which the defective sight has been due to disease, as to brain trouble producing convulsions in early life, or to head complications arising in the course of scarlet fever, or diphtheria, or some other malady, in all of which the ophthalmoscope commonly reveals some relics of a past storm, in the shape of changes in the condition of the optic nerves themselves. Before the invention of the ophthalmoscope, when the interior of the eye was invisible, cases of blindness without any manifest change in the eye were classed together under the unmeaning term of "amaurosis" (*i.e.* obscurity), a condition once defined by Walther as that in which "the patient sees nothing, and the doctor also nothing," or which was described in the well-known words of Milton's sonnet to Cyriac Skinner :—

> these eyes, tho' clear,
> To outward view, of blemish or of spot,
> Bereft of light, their seeing have forgot,
> Nor to their idle orbs doth sight appear
> Of sun, or moon, or star, throughout the year,
> Or man or woman.

At the present day, in cases of blindness, the doctor always "sees something," but in cases of merely defective sight he does not always do so, and those in which he does not are still described as "amblyopia," a meaningless word which may be regarded as a first cousin to the exploded "amaurosis," but which serves conveniently enough to express the fact of defective vision in eyes which do not present any manifest or

even discoverable change. It is not uncommon, for example, for a squinting eye to be amblyopic, even to the extent of being practically useless, and for its condition to remain unknown to ordinarily unobservant parents. We see also, I believe, something which might be described as amblyopia as a consequence of limited and slovenly use of the eyes, such that their receptivity has never been developed to the extent to which it might have been in more favourable circumstances. The cases in which the visual faculty is thus dormant or undeveloped may not unfrequently undergo great improvement under the stimulus of carefully conducted and regular exercise; and it is perhaps only by the occurrence or non-occurrence of improvement under favourable conditions that they can be certainly distinguished from others in which the defect, although not amounting to blindness, is the outcome of conditions which would have led to blindness if they had been carried somewhat farther, and which are only invisible by reason of the still defective character of our methods of examination. The optic nerve and retina can only be seen, in the living eye, under an enlargement of about thirteen diameters; and this is certainly sometimes insufficient to reveal changes by which sight might be seriously prejudiced.

We shall see hereafter that flat eye is one of the most frequent causes of squint; and it often happens that of the two eyes of the same person, only one of which appears to squint, the squinting eye is the more flat of the two, and is at the same time in a high degree amblyopic. The explanation of such cases is probably that, inasmuch as the effort of accommodation is governed

by the central nervous system, and can apparently only be made in both eyes to the same extent, it is never made in the flatter of the two to an extent sufficient to provide its retina with clear images, and thus with the visual exercise dependent upon receiving and recognising them. If, for example, the flatness of the right eye required for its correction an effort of accommodation equivalent to the presence of a glass lens of twenty inches focal length, while that of the left eye required twice this, or an effort equal to the presence of a glass lens of ten inches focal length, it is easily conceivable that the muscular effort of accommodation, governed, as it appears to be, by the demands of vision, would always be arrested as soon as these demands were satisfied for the right eye, and would never be carried so far as to satisfy those of the left. In such conditions, the left eye would never receive a clear retinal image, and would never be enabled to exercise the function of defined and accurate seeing. It is easily conceivable that its powers, thus habitually unemployed, would remain to a great extent undeveloped; and also that, by covering the right eye, and thus compelling the left to work, they might to a great extent be recovered and utilised. I have met with more than one example of this kind, in which a flat eye possessing only very imperfect vision has been brought into perfect usefulness by the loss of its fellow, and by the compulsion to work which was in this way thrown upon it.

Another form of defective vision arising from some fault in the nervous apparatus, but the precise nature of which is very imperfectly apprehended, is that which is known as colour-blindness. It is a matter of elemen-

tary knowledge that the perception of differences of colour depends upon the different impressions made upon the eye by the impact of light-waves of different length. If the wave-length be about 686 millionths of a millimetre, the resulting impression upon our sense is called red. If the wave-length be less, or only 526 millionths of a millimetre, the resulting impression is called green. If the wave-length be still less, say only 430 millionths of a millimetre, the resulting impression is called violet. If waves of the three lengths above mentioned be mingled together in certain proportions, and enter the eye together, the resulting impression is called white. If the proportions of the admixture are varied, so that one or two of the wave-lengths mentioned are present in excess or in deficiency, some one of the innumerable "colours" with which we are acquainted will be produced. The condition called colour-blindness is that in which the eye does not respond, or responds only incompletely, to light of some particular wave-length, and therefore does not "see" it, either separately or by its effect in combinations. The condition affects colour-perception only, and is not only compatible with, but is commonly associated with, perfectly normal form vision, or vision for the ordinary black and white test objects, so that colour-blindness is not detected unless specially looked for. It is curious, and at first sight seems surprising, that it may even be quite unknown to the subject of it, but the fact that this is so rests upon a confusion between memory of the names of colours, and the power of visually distinguishing them. A person who is red-blind, for example, has never seen red as a colour, and his want of power to see it causes him to lose

a certain amount of the general luminosity of all colours in which red is a notable constituent. The red of a rose, for example, would only differ from the green of the leaves, to his perception, by being less luminous, or darker, but he would have heard roses called red all his life, and would call them so himself, although the appearance they presented to him would be that of a darker shade of green. South's phrase, "the terrible imposture and force of words," is singularly appropriate to questions of colour; and the only real test of colour-vision is the power to match colours correctly, without the slightest reference to what they may be called. The most convenient test, that devised by Holmgren, consists of a number of skeins of Berlin wool, of various colours and shades, thrown into a heap in good daylight, and the person tested is told to select from the heap a few approximate matches to skeins selected for the purpose. The first of the selected skeins should be a very pale green, that is, a green much diluted with white, and, if only true greens are chosen as matches to it, normal colour-vision is assured. The person tested should be told to choose all skeins that are of the same colour, without regard to slight differences of shade; and the colour-blind will invariably place drabs and fawn colours with the green. If the examination with the green be passed satisfactorily, nothing more need be done; but if false matches are made with the green, a light purple skein should next be given, and then one of bright red, with a view to ascertain the portion of the colour spectrum with regard to which the blindness is most complete. It is easy to discover that some colour-blind persons are blind to red,

while others are blind to green; but either condition introduces an element of confusion into all colours, because the pure tints of the spectrum are seldom or never presented to us except by designed experiment, and the invisibility of one chief element in an admixture completely alters the effect of the rest. Blindness to blue has occasionally been met with, but it is a very rare condition.

The most interesting fact about colour-blindness is that it appears to be entirely a matter of formation. It occurs among all nationalities, in proportions ranging from about 2 per cent. of the more wealthy to about 4 per cent. of the labouring classes of males, and in about one-tenth of that proportion of females; and it is probable that a certain incompleteness or indefiniteness of colour-vision may be somewhat more widely diffused. Most ladies could mention others among their acquaintances in whom a sense of colour harmonies, at least, does not habitually display itself in their attire. Many attempts have been made to correct colour-blindness by various expedients, such as by looking through media coloured by fuchsine, or to improve the deficient sense by training, but none of them has ever been rewarded by the slightest measure of success. A person who is born colour-blind will remain so; and, in some positions, as when it becomes his duty to recognise the colours of signals, his defect may be a source of serious disaster. In military service, when it may often be important to recognise the colours of uniforms seen from a distance, defective colour-vision is perhaps as dangerous as in almost any other position.

CHAPTER III.

CONSEQUENCES OF DEFECTIVE VISION.

As regards education, the consequences of defective vision may almost be summed up in the single statement that a child who does not see as well as its companions is handicapped in all the pursuits which it has in common with them; but, in considering the varieties of defect, it is necessary somewhat to expand this general statement.

In "short-sight" the subject of the affection can see quite well over a limited range of distance. He can see the details of very minute objects within this limited range; his power to bring them near to the eyes giving him a large retinal image, which, in a modified way, produces somewhat the effect of looking through a magnifier. Let it be said that his far-point is ten inches from his eyes. He will probably be able to read the smallest print at any range between five inches and ten; but everything beyond ten inches will be somewhat indistinct, and everything beyond three or four feet will be a mere blur. At school, in the ordinary position of a class, he cannot see what is written upon a blackboard; and a cricket ball appears to come suddenly out of nowhere. In an ordinary room, he would be unable to see the details, and hence would be unable to appreciate the merits, of pictures upon the walls. The human face, at

the distance which we generally preserve from those around us, would be to him an expressionless patch; and, never seeing its expression, he would grow up without any power of estimating character from observation. He would lose most of the beauties of nature, and most of the beauties of art. If he lived in the country, he would be unable to observe the habits of wild creatures; he would not see a bird on a spray, or a rabbit crossing a ride, or a snake in the grass. If he lived in a town, he would be unable to take in the effect of a fine building, or to see whether the cab which he desired to hail was occupied or empty. In short, the great world around him would not appeal to the sense by which we especially obtain some knowledge of it, and, in the absence of this appeal, certain natural consequences follow. The short-sighted child does not care to look at what he cannot see; and hence it is frequently his delight to gather himself nose and knees together in a dark corner of a room, and there to pore over a book. As he grows up, his physical infirmity reacts more and more upon his mental condition; and he seldom attains comprehensiveness of view. A common form of speech is founded upon the universal experience of mankind. We carry over the term expressive of a physical defect to describe a mental one; and, at least in the origin of the transference, we did so because we had learnt from observation that the former usually implied the latter. The rich girl who cannot see the warning which Nature has written on the countenance of the fortune-hunter; the barrister who cannot see when he is irritating the jury; the preacher who cannot see when he is wearying his congregation, all are fairly comparable to the man

who cannot forecast what will be the inevitable consequences of his actions. All are "short-sighted," and the incapacity to see physically, the compulsion to live within a narrow visual circle, is constantly associated with the inability to transcend that circle by the aid of imagination. Pope justly argues that "blind Mæonides" could not have been blind from birth, whatever he may have become. "With what an exactness do his cities stand, his mountains rise, his rivers wind, and his regions lie extended. He must certainly have beheld the creation, considered it with a long attention, and enriched his fancy by the most sensible knowledge of those ideas which he makes the reader see while he but describes them."

If there be one sphere of human activity for which, rather than another, short-sight should be regarded as a hopeless disqualification, it is the conduct of war; and yet, in defiance of experience, our military authorities persist in giving commissions to short-sighted men. It would seem easy and natural to follow the example of the Navy, in which normal vision with each eye singly is insisted upon; but common sense has not yet gained this amount of ascendency at the War Office. Worse still, young short-sighted officers are discouraged from wearing glasses; and hence their minds become confirmed in the errors and incapacities which uncorrected short-sight produces, and which may, to a great extent at least, be obviated by its habitual correction. A few years ago the army requirement was that the candidate for a commission should have, with each eye, at least one-sixth of normal vision, and that this should be capable of such improvement by glasses as to become

normal with one eye and half normal with the other. Recently, the requirement for unaided vision has been raised to one-fourth; an amount which is still sufficient to open up almost inconceivable possibilities of blundering in the presence of an enemy. At the battle of the Alma, it was the short-sightedness of Sir George Brown which caused the Light Division to become hopelessly "jammed in and entangled with the 2nd Division," and Kinglake records how, and with what consequences, the Division was absolutely taken into action by three short-sighted generals. At Inkerman it was the short-sightedness of Sir George Cathcart, which, at a very critical moment, led him to act upon his own mistaken impression instead of upon the orders which he had received from Lord Raglan. It can hardly be doubted that, in the recent campaign in South Africa, more than one of the "regrettable incidents" which have been recorded must have had its origin in the same abounding source of error and confusion.

Perhaps the most unfortunate characteristic of short-sight is its tendency to be progressive. The approximation of objects which it entails, when continually required, as it is in reading, writing, and the pursuit of many other occupations, implies a constant high tension of the inner muscles of the eyeballs, for the purpose of maintaining the necessary convergence; and this tension, by virtue of the pull which the muscles exert upon the points of their insertion, mechanically produces a tendency to expansion of the posterior hemisphere of the eye, and a consequent progressive elongation of its antero-posterior axis; in other words, an increase of the very defect of shape on which short-

sight depends, and a consequent increase in the degree of the defect and in the nearness of the far-point. Popular traditions die hard; and it was commonly believed, until a comparatively recent period, that short-sighted eyes offered some sort of advantage to their possessor; the obvious one, that they could make out fine details which people with normal eyes could see only with difficulty, being often quoted. This power, whatever it may be worth, was the manifest consequence of being able to bring the fine details sufficiently near to obtain from them comparatively large retinal images; and optically speaking, it only placed the short-sighted eye in the position of a normal eye aided by a magnifying glass. On the other side of the question the preponderance is overwhelming. In only a small proportion of short-sighted eyes is it possible to raise distant vision to normal acuteness by glasses; and examination by the ophthalmoscope reveals changes incidental to disease in an enormously large proportion of them. Professor Donders, forty years ago, after examining 2,500 short-sighted eyes, laid down the general proposition that "a short-sighted eye is a diseased eye"; and, to whatever extent this may have ceased to be true, the change has been wrought solely by the fact that better knowledge of the conditions involved has led to the almost universal use of spectacles, not merely for the purpose of obviating the manifest inconveniences of the condition, but for the purpose of preventing its injurious effects, of which not the least conspicuous, when once a high degree of short-sight has been reached, is the terrible affection known as detachment of the retina, by which, in the majority of instances of its occurrence, incurable blindness is produced.

Among the incidental ill consequences of short-sight, during the period of education, must be reckoned the necessity which it entails of reading and writing in objectionable postures, as with bowed head, bended neck, and chest so placed as to restrain the natural inspiratory movements. In such positions not only is the breathing impeded, and the blood imperfectly aerated, but the access to and the return of blood from the brain are hindered by the position of the great vessels of the neck, so that the general vitality of the body, and the special nutrition of the organ to which teachers are supposed chiefly to appeal, are alike injuriously affected.

In children and young persons, in whom the crystalline lens is highly flexible and elastic, and in whom the muscles of accommodation are often well developed, a moderate amount of flatness of the eyes, even when associated with some astigmatism, may easily pass unnoticed. The question is purely one of degree; of the amount of flatness to be overcome on the one hand, and of the amount of muscular power available on the other, combined, of course, with the duration of the period over which the effort is required. But when, either from the degree of the defect itself, or from muscular incapacity to overcome it, flat eye makes itself felt, it becomes at once a cause of very characteristic symptoms, and a serious impediment to the conduct of education. Distant vision in such cases is often normal, but the eyes are manifestly harassed and worried by near work, and often become flushed and watery when it is attempted. The child seeks the best light available. I have known one instance in which a little girl, who

had to puzzle out her lessons in a room lighted by a gas-burner hanging from the ceiling, got into the way of standing on a chair under the pendant in order to bring her book as close to the flame as possible. The page will generally be held very close to the eyes; or, what is still worse, the head will be brought close to the table, into a position bearing a deceptive resemblance to that produced by short-sight, but in which, as Professor Donders first pointed out, the larger retinal images more than compensate for the less accurate definition. In order to maintain single vision at this short distance, a high degree of convergence of the axes of vision is required; calling for strenuous and sustained effort of the inner straight muscles of the eyeballs, and adding this strain to that already cast upon the muscles of accommodation. Mention has been made of the manner in which the convergence incidental to short-sight tends to increase the degree of the defect, and the convergence incidental to flat eye acts in a precisely similar manner. Under its influence it is not uncommon to see the original flatness of the eyeball disappear, and ultimately pass over into elongation and consequent short-sight, which, when thus produced, is even more liable to attain a high degree, and to be attended by changes ultimately perilous to vision, than when it existed as a matter of original proportion.

In eyes of natural formation, an effort of accommodation is only needed for objects which are brought near to them, and for which, in order to maintain singleness of vision, a corresponding effort of convergence is required. The two functions, accommodation and convergence, are almost inseparably united; and it is hardly

possible to exert one without the other. In cases of flat eye, where accommodation is necessary even for distance, its constant exercise calls upon the convergence muscles for corresponding activity, and they become developed by action until they are liable altogether to overpower their natural antagonists on the other sides of the eyeballs. The result is the inward deviation of one eye which is described as "squint". The constantly exercised internal muscles become preponderant; and the resting position of the eyes becomes one of convergence to a near point. This position again entails double vision of all objects lying beyond that near point, and the double vision is so disturbing that an instinctive effort is made for its relief. The result of this effort is to roll one eye far in towards the nose when the other assumes a central position, and the squint, which at first is often alternating, usually becomes fixed in the eye which has the highest degree of hypermetropia, or which, from any cause, has the lowest acuteness of vision. It is a little curious to consider that a defect which is now known to be altogether dependent upon the shape of the eyeball, and to be curable either by glasses or by an operation, was commonly regarded in the earlier part of the last century as an indication of moral obliquity. The villain of romance was always furnished with a squint; and this was looked upon as Nature's warning with regard to his character and tendencies.

While such may be the physical consequences of flat eye upon the organ itself, it must be almost obvious that conditions which render sustained near vision impossible, except at the cost of efforts which, considering the small size and relative weakness of the muscles

concerned, may fairly be described as strenuous, must be excessively disturbing to any educational process which aims at the regular conversion of visual impressions into ideas. A child compelled to struggle over the sign is almost compelled to be negligent of the thing signified; and cannot be expected to hold his own against classmates who are more fortunately circumstanced. His nervous energies cannot be directed at the same time and with equal force into two different channels; and, it being difficult for him to see, it becomes almost impossible for him at once to see and to think. Many years ago I published the statement that I had never met with an instance of a child with defective sight who had not been systematically bullied or punished in the schoolroom for the natural and unavoidable consequences of his defect. I could not now repeat this statement without much qualification; for both parents and teachers are more alive to such possibilities than once they were; but it is still only too true in many cases, and is probably more true of teachers who would describe themselves, or at least think of themselves, as belonging to the higher walks of their profession, than of the more humble ones who, on the whole, are less likely to be "wiser in their own conceit than seven men who can render a reason". An architect or an engineer bases all his calculations upon his knowledge of the strength of his materials: and a teacher should do the same. The very first question to be asked, in relation to a new pupil, should be whether his reception of sense impressions is natural and easy, or is only attained by a laborious and to some extent exhausting struggle against difficulties incidental to formation.

In the year 1895 I made for the Education Department an investigation of the acuteness of vision and the state of the eyeballs of children in London elementary schools. Twenty-five schools, containing 8,125 children, were selected in various parts of the metropolis; and the teachers were furnished with test-types, and were instructed to institute a preliminary examination, and to separate the children with normal from the children with subnormal vision. The former would be likely to include many with negligible or only moderate degrees of flatness; the latter would include all the other forms of defect.

The general results of the examinations made by the teachers were as follows: out of 8,125 children tested, 3,181, or 39·15 per cent., were found to have normal vision in both eyes; 1,016, or 12·5 per cent., had normal vision in the right eye and subnormal in the left; 700, or 8·6 per cent., had normal vision in the left eye and subnormal in the right; and 3,228, or 39·7 per cent., had subnormal vision in both eyes. Comparing the sexes, the total was made up of 3,928 boys and 4,197 girls, of whom the boys had normal vision in both eyes in 1,718, or 43·7 per cent., and the girls only in 1,403, or 33·4 per cent. Subnormal vision in both eyes was found in 1,332 boys, or 33·9 per cent., and in 1,896 girls, or 45·1 per cent. Normal right eyes with subnormal left were found in 522, or 13·3 per cent., of boys, and and in 494, or 11·77 per cent., of girls; while subnormal right eyes with normal left were found in 356, or 9·0 per cent., of boys, and in 344, or 8·2 per cent., of girls.

Of the 4,944 children with defective vision, rather more than half (2,441) were afterwards carefully ex-

amined either by myself or by Mr. Belcher Hickman, who kindly assisted me. The work occupied us for three or four afternoons of each week for nearly the whole of the summer, and the acuteness of vision in each eye, together with the amount of short-sight, of flatness, or of astigmatism, was carefully ascertained and recorded. I was early struck by the fact that, in a large proportion of cases, the subnormality of vision was greater than the defect of shape of the eyeball would explain, and I soon began to refer it to a certain retinal torpidity arising from want of exercise. These London children never saw distant objects, and were never stimulated to pay careful attention to small retinal images. They saw the other side of the street, or perhaps fifty or a hundred yards along its course, and they saw the passing carts and omnibuses, and the oranges on a costermonger's barrow, but they never looked for an object on a distant horizon, or for a cunningly concealed bird's nest, or for berries lurking among foliage in a hedgerow. They had never been taught to look at the minute characteristics of a near object, in the way, for example, in which children of the better classes would be taught to notice and admire the striation of the petals of flowers, or the venation of leaves, or the designs on the plumage of birds or of insects. The perception of an interval was only possible to them when its image was large enough to cover more than a single cone of the retina, while their colour-sense was comparatively undeveloped, and did not extend to the rapid recognition of minute differences in the tints of adjacent small surfaces. Under the conviction that I had rightly interpreted the facts, I

determined to pay a visit of inspection to a country school, and selected one at Cheshunt for the purpose. I found there 198 children, 114 girls and 84 boys, and tested them for vision and refraction. The examination was made on a dull afternoon in February, and I therefore placed test-types, which on a bright day should have been read at sixteen feet, only fifteen feet from the children. With this indulgence, only four boys out of the 84, and only twelve girls out of the 114, showed subnormal vision, which, in the cases in which it existed, was explicable by decided errors of refraction. So far as this one school was concerned, my hypothesis was entirely supported, but it is obvious that a more extended inquiry would be necessary before it could be assumed that similar conditions would be found universally.

I have somewhere read of a classification of school children, made by schoolmasters themselves, into "quick-intelligent, intelligent, slow-intelligent, slow, slow-dull, and very dull," and I think it is tolerably obvious that this classification, in so far as it may be supposed to be descriptive of mental characteristics, should be revised by reference to standards of sense perception, or should at least be further analysed into the cases in which "slowness" was due to the tardy reception of an idea, and those in which it was due to the tardy or uncertain reception of a sensation. If I may trespass for a moment upon the field of my coadjutor, it would be to point out that the traditional boy, who described the equator as "a menagerie lion running round the earth," was probably neither dull nor stupid, but that he had at once and completely grasped what he thought

he had heard. Analogous errors might easily be dependent upon defective vision, and, with regard to errors of all sorts, it should be remembered that the reception of a sense impression is a process requiring time, and that the amount of time required varies in different persons, and admits of being greatly abbreviated by practice. Physiologists say that there are certain paths of conduction in the brain, and that these are traversed the more quickly and the more easily the more they are trodden. Many ingenious instruments have been devised for measuring the time required for the passage of a sense impression to the brain, and for its issue in an idea or in a movement, but the facts underlying them are patent to common observation. We all know that the visual recognition of any object is greatly promoted by its familiarity, and it is not an uncommon educational error for the pace of the teacher to outstrip the receptive capacity of the pupil. When sensation B is presented before sensation A has been completely taken in, the result is a confusion somewhat analogous to that which is produced by listening to rapid speech in an unfamiliar language; and it is evident that a child slightly below the average in mere quickness of sense perception, but fully equal to the average in real mental endowment, might be very unfairly handicapped by being placed in a class of average children, in which no allowance was made for his personal requirement.

It seems to follow that, as the very basis of school teaching, some attempt should be made to ascertain the visual capacity of the scholar, not only as regards acuteness, which is easily measurable and can be expressed

in numerical terms with absolute precision, but also as regards rapidity of perception, which, although it can only be measured exactly by the careful application of refined tests, yet admits of easy approximative statement of sufficient correctness for all practical purposes. An average child, placed at a proper distance from a line of test letters, so that he can see them individually without difficulty, will occupy a certain time in reading them aloud, one by one, either forward or backward; and, if any attempt be made to hurry him beyond his capacity, he will make mistakes. The number of seconds required for the correct reading, say of a line of twenty letters, placed at or near the limit of distinct vision for their size, would be easily determined by a watch, and would be approximately determined even without one after a very small amount of experience. For all children of the better classes, all, that is to say, whose parents are of sufficient education or intelligence, the determination of the acuteness of vision, and of the rapidity of perception, should be made for each eye separately in the nursery, at least by the age of eight years, and in this way much subsequent disappointment would be saved. Quite lately, for example, I was consulted about the case of a lad destined for the Royal Navy, whose education had been expensively conducted with reference to that intention, and who was rejected as a naval cadet on the score of defective vision. I found him to be normal sighted with one eye, but short-sighted with the other, so that his rejection was in accordance with the regulations, and might have been foreseen long before his special training for his supposed future calling had commenced. His parents, cultivated

people of distinguished position, and highly solicitous for the welfare of their children, were absolutely without suspicion of the defect. The boy was always supposed to see as well as other people, and his sight had never been tested. In the class of children who are taught at public elementary schools, domestic attention to vision can hardly be expected; and with them the deficiencies of home should be supplied by the teacher. At every school, indeed, the vision of every new pupil should be tested and recorded on admission, as affording knowledge of facts absolutely essential to the proper conduct of his education, or to any adjustment of the requirements made upon him to his power of fulfilling them. Such a test would be like the suspended metal arches seen in the goods sheds of railways, which represent those of the bridges on the permanent way. If a loaded waggon strikes the former, it would be unable to pass under the latter. In like manner, a child inferior to his classmates in acuteness of vision, or in rapidity of visual perception, would be manifestly unable to keep pace with them in their work. The methods employed in his instruction, the amount of work exacted from him in a given time, and perhaps his ultimate destination in life, should all be governed by a complete recognition of the nature and degree of his defect.

It is not too much to say that the cases of all children, in whom either defect of vision or undue slowness of perception is distinctly noticeable, should at once be made the subject of medical investigation, especially for the purpose of determining, in the former case, whether and under what limits or for what purposes the use of spectacles is desirable, and, in the latter,

whether the slowness is confined to the recognition of visual impressions, or extends generally to other operations of the nervous system, and to the receptivity of other organs of sense. In the case of the children of well-to-do people, of course, such investigation is always within the reach of the parents ; and, in the case of the poor, there would be sound economy in its being provided from public funds. In large centres of population, eye hospitals are usually available; but it may be reasonably maintained that the requirement is not one which they should be called upon to fulfil. Upon its fulfilment depends whether the public funds devoted to education are, in the cases of the particular children concerned, well employed or wasted ; and the public duty of paying for education should, in my judgment, include the duty of paying to ascertain the presence of difficulties in the way of conducting it, and the methods by which those difficulties may be set aside.

A certain proportion of cases will be met with among children, and a still larger proportion among adults, in which there is no manifest defect of vision as tested by types or dots, but in which the power of continuing to apply the eyes to near work is extremely limited, and in which either general headache, or pains in the eyes themselves, are produced by a comparatively short period of effort. Such cases ought not to be overlooked by any careful teacher, especially as, when the pain experienced is in the eyes themselves, these almost always become flushed and irritated in appearance. Such cases usually depend upon one of two conditions, either a moderate degree of flatness, which the muscle of accommodation is able completely to overcome for distant objects or for

the short effort demanded in testing, but is unable to overcome continuously for near objects without undue fatigue, or else from some want of harmony in the action of the external muscles, by which the eyes should be enabled to work comfortably in combination. The most common form of this defect depends upon comparative weakness of the muscles by which convergence is maintained, but this is by no means the only one, and all such cases fall under the category of those requiring medical advice. Specially constructed prismatic spectacles, or an operation upon the muscles, or even the use of one eye alone for reading purposes, may all be indicated under varying circumstances, and no general rule for the management of such conditions can be laid down. They are among the most complicated that fall under the observation of ophthalmic surgeons; and it is probable that, when occurring among the poor, they should rather be regarded as limiting the area of profitable employment than as offering any assured prospect of relief by surgical or optical means.

As a general statement, therefore, it may safely be said that the consequences of defective vision in childhood are the production of more or less pain, headache, and incapacity for mental exertion, together with slowness in the accomplishment of work which would be well within the powers of normally sighted pupils; the production of faulty positions of the body, calculated to interfere with symmetry and with chest expansion, as well as with a proper supply of blood to the brain; and, in some cases, an incapacity to follow pursuits, industrial or mechanical, for which the pupil was supposed to be specially prepared by education. It seems to follow,

not only that care should be taken in all schools to examine into the state of vision in each pupil, but also to adapt the methods of teaching to the individual requirements of the subnormally sighted, and to allow their visual capacities to govern the nature of the callings for which they are supposed to be prepared.

CHAPTER IV.

AIDS TO VISION.

The assertion that the eyes of children during the educational period of life should be called upon to work only under conditions favourable to the exercise and the development of their functions, is one which may fairly be described as incontrovertible, and it unquestionably applies to children in whom the sight is defective even more than to those in whom no defect is manifest. It follows that all children should have good light, and seats and desks adapted to their stature and to the positions necessary for their work, and that children suffering from optical defects should have those defects corrected, whenever possible, by optical appliances.

Speaking generally, the fault of shape of a short-sighted eye may be corrected, optically speaking, by a concave lens, and the fault of shape of a flat eye by a convex lens, in either case of a strength corresponding to the degree of the defect. As a rule, a lens of the focal length of one metre is required for every third of a millimetre by which the axis of the eyeball is either too long or too short for the power of its refractive media, and the problem, thus regarded, is simply an optical one, capable of being solved, as a matter of simple calculation, by any person who is acquainted with the mechanical principles involved. In other words, it is easy to know what strength of glass

an eye requires for its conversion into a comparatively perfect optical apparatus.

Mechanical calculations of this kind, however, are apt to be vitiated by the fact that the eye, although primarily an optical instrument, is also a living organ, and a part of a complicated nervous mechanism, of a kind which is liable to be affected, in various ways, by conditions acting upon the general health. It is not sufficient to determine that an eye is a millimetre too long in its antero-posterior axis, and, on this ground, to give it a concave lens of a third of a metre in focal length, but it is also necessary to take into account the living organism of which it forms part, and the circumstances favourable or unfavourable to its health and activity. It is for this reason that the business of prescribing spectacles cannot safely be entrusted to an optician, however much he may be a master of his proper craft. He may be relied upon, as a rule, to correct the merely mechanical conditions, arising from disproportion in the shape of the eye, by which sight is interfered with ; but he cannot be relied upon to discover the vital conditions by which the mechanical ones may be modified in their operation. He is necessarily liable to overlook the beginnings of disease, and is found not very seldom actually to overlook even its pronounced forms and later stages. A curious example of this has even rooted itself into popular beliefs on the subject of sight and spectacles.

It is generally known that every person with normal eyes, on reaching the age of forty-five or fifty, requires the use of convex spectacles for reading or needlework ; and the cause of this requirement is the gradual harden-

ing of the crystalline lens, with corresponding diminution of the power to increase its curvature under the action of the ciliary muscle. In a disease called glaucoma, which, until a cure for it was obtained by operation, always entailed gradual and ultimately complete loss of sight, the shrinkage of accommodation is more rapid than in other cases, and hence one of the early signs of the more chronic or slowly progressive forms of glaucoma is a demand for stronger and stronger glasses at short intervals of time. It became known to spectacle-makers, as a matter of observation, that customers who often came in search of stronger and stronger spectacles were liable soon to become blind, and the makers somewhat rashly assumed that the strong spectacles were to blame for the result. They had no means of recognising the disease, and they mistook an effect for a cause, with the consequence that they were perpetually uttering groundless cautions against the use of spectacles that were "too strong". The harm was done, not by the use of strong spectacles, but by delay in having recourse to operative treatment; and the history of these cases shows the necessity of attaining a complete knowledge of the existing conditions, physiological and pathological as well as optical, before proceeding to give advice for the latter, based upon the comfortable assumption that the former are absent or may be neglected. It is always necessary to bear in mind the possibility that spectacles, even if they assist the eyes to work, may at the same time enable them to work to their own ultimate detriment, or in the presence of conditions which, as soon as they are recognised and understood, are seen to call for rest and treatment rather than for aids to activity.

Of late years, spectacles of the character known as "prismatic," and either with or without added convexity or concavity, have been largely employed for the alleviation of conditions in which the maintenance of combined action of the two eyes, on near and sometimes even on distant objects, has been rendered difficult by a real or supposed absence of harmony among the external muscles which are concerned in guiding and directing them; and, especially in America, good results are said to have been obtained in such cases by operations upon the muscles, operations sometimes intended to strengthen those which were weak by advancing their points of attachment, or sometimes to strengthen them relatively by diminishing the power of their antagonists. Proceedings of the latter class must, of course, be confined to surgeons, who can properly accept responsibility for their performance; but a good many spectacle-makers have imagined that it might be within the proper scope of their activity to test the actions of the ocular muscles, and to prescribe elaborate prismatic and other glasses for the rectification of any errors in their performance. The results, so far as they have fallen under my observation, have on the whole been the reverse of satisfactory; and this has never been more manifest than after very painstaking endeavours to correct small errors to which far too large a degree of importance had been attached by those who fancied that they had discovered them. I believe the truth to be that Nature, like Law, *de minimis non curat*, and that the useful application of mechanical means is in the great majority of instances limited to the correction of gross and obvious defects. In few people, for example, is it impossible to detect

some shade of difference between the two eyes; but in fewer still is it possible to correct the inequality by difference of glasses without entailing discomfort upon the wearer.

Among mechanical contrivances to be noted, however, and which may often be usefully employed in the case of children, are the various forms of head rest which serve to maintain a proper distance between the eyes and the objects to which they are directed. As already explained, the short-sighted child is compelled to bring the eyes near to a page in order to see the characters, and the flat-eyed child is induced to do the same for the sake of obtaining larger images. In both, the wearing of proper spectacles takes away the necessity, but it does not always suffice to change the practice. A child may sit down to work with the best intentions; but, when the mind becomes absorbed in the subject-matter of a book or of a lesson, it is very common for the muscles unconsciously to bring the body into an accustomed posture, and hence for the vicious positions once necessary to be retained, and the evil contingent upon them, the increase or the production of short-sight, to be produced. In home education, and with a careful teacher, it may be sufficient to have recourse to occasional admonition until the bad habit is broken through; but, in many circumstances, a head-rest which mechanically prevents undue approximation will be useful or even necessary. Sometimes I direct children to rest an elbow on the table and to support the chin or forehead with the hand; and, when this is not sufficient, perhaps the best contrivance is one made by the optician Kallmann of Munich, and described by him as a "Durch-

sichtsstativ ". It consists of an upright brass stem, screwed to the edge of the table, and terminating in an oval ring covered with india-rubber, the upper part of which supports the forehead while the face looks through the aperture. It may be obtained in London from Messrs. Baker, of 244 High Holborn. For adults, in whom it is desired to maintain a measured distance between the eyes and a printed book, a convenient means of doing so is afforded by what is known as a "reading easel," a light frame of wood suspended around the neck by a cord, and resting upon the chest of the wearer. It is hardly necessary to mention that, for the preservation of good positions in either reading or writing, the heights both of the seat and of the desk or table should bear due relation to the height of the worker, and that the light should be set in a convenient place, usually either upon the left front, or behind and somewhat to the left side. A careful inspection even of designed schoolrooms would show, in only too many instances, that the problem of how to afford equal illumination to the occupants of all the seats had not been present to the mind of the architect; and it is obvious that in the schoolroom of a private house, built with no reference to the purposes to which it is applied, the difficulties of proper illumination must sometimes be considerable. It may not be undesirable to bear in mind, in this relation, that the great prevalence of short-sight in Germany is believed to be mainly due to the dark schoolrooms of many of the older towns, and to the consequent approximation of the children's eyes to their work, in order to obtain from the page sufficient reflected light for the easy deciphering of the letterpress.

CHAPTER V.

THE CULTIVATION OF VISION.

THE work of endeavouring to improve the vision of children must be undertaken, like all other endeavours to obtain increased expertness in the performance of operations guided by the senses, by means of exercises, either designed for the purpose, or capable of incidentally promoting it. It must be borne in mind that two separate aims are to be kept in view; aims essentially distinct, and yet often to be attained in combination; namely, *acuteness* of seeing, or the power to recognise objects which subtend small visual angles, and *quickness* of seeing, or the power to recognise rapidly whatever may come within the visual field. The only way, probably, of really interesting children in designed exercises for either purpose would be to render these exercises competitive, with prizes or rewards for proficiency, a course which I have often declared to be also suitable for adults. A moment's reflection would show any one that quick and accurate seeing is as much a form of athleticism as running or jumping, that in many circumstances of life it is calculated to be more useful to its possessor than any degree of excellence in running or jumping, and that it is to be cultivated precisely in the same way, by the combined effects of exercise and of emulation.

Perhaps the greatest difficulty, in the way of the general cultivation of vision in children, may be said to depend upon the widely diffused supposition that the faculty comes, so to speak, of itself; as well as upon the almost universal want of knowledge of any standard to which its performance can be brought. Everybody, as I have written on former occasions, has at least a rough general idea of some of the physical capacities proper to a boy of ten years old, and would know about how far or how high he might be expected to jump, how fast he might be expected to run, how great a distance he might walk, or what weight he might carry. Not one person in ten thousand would have the slightest idea of the size of the object which he ought to see at a hundred yards away. The defective vision of children, however pronounced, constantly comes as a surprise to the parents under whose care their lives have been spent, and who have never once given a single thought to the subject. Not long ago, a girl of fourteen was brought to me for advice, with the history that she and her brothers had been taken for a trip to the Continent during their school holidays. "There was," said the mother, "a perpetual chorus of exclamation from the boys about the things which they pointed out to their sister, and which she could not see. It was 'Don't you see this?' and 'Don't you see that?' and 'How *stupid* you are!' until we began to think there must really be something the matter." The girl was short-sighted, with a far-point only ten inches from her eyes, and, but for that journey, it is probable that none of her family would have discovered her condition. It is high time that, at least in the nurseries and schoolrooms of educated people,

such discoveries should be made at the earliest possible period. All that would be necessary for the purpose would be a few printed letters hung against the nursery wall, and a few trials to determine whether they could be deciphered by each child at a proper distance. In all schools, public or private, elementary or advanced, the testing and recording of the vision of every new pupil should be as much a matter of routine as the entering of his name, or of the names of those who were responsible for his attendance.

A cheap and convenient apparatus for commencing the early training of vision in children would be that which is employed for the purpose of testing in the French Navy. It consists of a card on which are printed twelve rows of letters, containing twelve in each row, and of a size to be read easily at a distance of twenty feet. The intervals between the successive letters of each line are as wide as the spaces occupied by the letters themselves; and the intervals between successive lines are as wide as the height of the letters. A person placed at twenty feet from the letters, or, if it were necessary to render them plainer, placed even a little nearer, may be called upon to read along any one of the lines in a vertical, a horizontal, or a diagonal direction; and the time occupied not only in the reading, but previously in selecting and identifying the line mentioned by the instructor, affords an excellent test of the rapidity of vision, which, even with average children, will be found quickly to increase by practice. Room for competition is afforded either by the number of seconds required for reading a line, or by increasing the distance at which it is seen, or by reading backwards instead of

forwards ; the rapidity of movement of the eyes towards the right being in most people, evidently as a result of habit, somewhat greater than the rapidity of movement towards the left. A more advanced exercise might be furnished by moving objects, visible for a moment as they passed behind an opening in a screen, and a convenient and adjustable rate of movement may be attained by attaching the objects to a pendulum or to clockwork. A single letter, a group of letters, a word, a geometrical figure, a group of Burchardt's dots, a picture, may all be employed for this purpose ; and the magnitudes of the retinal images may be diminished by increasing the distance to the full limits of the visual capacity of the person tested. Simple contrivances of these or similar kinds will suggest themselves in infinite number when once the task of training the sight is seriously undertaken.

The cultivation of the colour sense is a matter which should at least be attempted in every school ; and, until the attempt is made, few people would be prepared for the deficiencies which will constantly be encountered. For the small percentage of children who are colour-blind, no instruction, as I have said already, will bring about any change in their condition ; but a very large percentage, who are not colour-blind, will be found to be amazingly ignorant of colour and amazingly unobservant with regard to it. The object of cultivating the colour sense is not so much for the sake of the mere accomplishment conferred, as for the sake of the increased readiness and accuracy of observation which every step of improvement will entail ; but both objects should, of course, be aimed at. The late Professor Virchow, many years ago, said "that he would urge, repeated in every

school term, the practical teaching of colours, for he had found the majority of young men incapable of defining with certainty the finer shades of the most common colours. It was exceptional that a medical student could tell whether a red shaded into a black, blue, or brown, or whether yellow shaded into gray, white, or green. This was a lamentable defect of the eye, very seldom dependent upon colour-blindness, but on ignorance of colours and lack of practice. It can readily be overcome by education." It is obvious that the kind of education required would be such as to cultivate attention to visual impressions generally, and to render the eyes more alert and more receptive in every direction in which they could be used.

The best method of educating the colour sense in children is by means of a chart and cards which were designed by Professor Magnus of Breslau, and which are largely in use both in Germany and in the United States of America. On the chart are arranged in nine rows from left to right the following colours: brown, crimson, red, orange, yellow, green, blue, violet, grey. Each is represented in five tones, commencing with a light one, and passing through three more saturated tones to a quite dark one. The colours are shown as ovals, about two inches by three, their long diameters horizontal. In order to simplify the instruction, no attempt at combination of these nine colours is at first made.

According to the instructions drawn up by Dr. Joy Jeffries, of Boston (Mass.), for use in the schools of America, the middle horizontal row is intended to represent the typical or standard colours. Above are two

lighter *tints*, and below two darker *shades*. Each oval on the chart is represented in duplicate on the accompanying coloured cards.

The chart is to be hung within the children's reach on a wall, in a good light, avoiding reflection as much as possible. The simplest form of exercise for a commencement is to distribute the cards, one to each child, and a child is then asked to match his card to the corresponding oval on the chart, or to the same coloured card in another child's hand. The class should watch, and decide upon his success. No names of colours should be used at first. After matching in this way, the cards may be returned to the table and redistributed, and the children again called upon to match the colour chart. This form of teaching is to be repeated day after day, until all or nearly all the children learn to recognise the principal colours. The exercise may be varied by pointing to one of the ovals on the chart, and asking a child to find one like it on the table, or in the hands of another child if the cards are distributed. As children will naturally seek the brightest colours, the teacher must take care that the more sombre are equally well learnt; and must remember that the scholars will forget the impression of the colours as they will forget any other impression. The ingenuity of the teacher will suggest many variations of the exercises, so as to retain the interest of the children till the perception and quick recognition of each typical colour are secured. Up to this point, no direct attempt should be made to teach colour names, though any knowledge of them offered by the children should be accepted and used, and any inquiry for a name should be answered. Perhaps nearly

all the names will thus be brought out incidentally, and each child may learn one or more. The instruction may now be continued by a series of simple exercises in which the name shall always be associated with the colour. The teacher points to one of the nine colours, gives its name, and asks a child to find a card of the same colour and to give its name when found.

When average quickness of vision is possessed, or has been attained or exceeded, few methods of further cultivation are better than that which has been described by Robert Houdin, the conjurer. He relates that he was accustomed to walk with his father past a shop, looking at it as they went, but not stopping; and that immediately afterwards they each wrote down the most complete list they could of the things that were on view in the window, comparing their lists, and going back to see what each had omitted. By dint of this kind of practice they both acquired the power of taking in at a glance a large number of unconnected particulars, and of seeing accurately as well as quickly, not only the objects which fell into the centre of the field of vision, but also many which could be only seen laterally. A time came when their lists were almost or quite complete, however numerous or dissimilar the objects which had to be included in them. Mr. Rudyard Kipling, in *Kim*, describes a somewhat similar exercise performed by glancing for a moment at a collection of things upon a table; and the underlying principle is in both instances obviously the same. Such expedients may be the best that can be used in towns; but in rural districts the opportunities for natural cultivation of the senses are innumerable, and should be em-

ployed just as sedulously as they are commonly utterly ignored and neglected. To call upon children for the most varied possible collection of wild flowers, of leaves, of berries, or of insects, or for the mere enumeration of the objects seen during a walk, would be among the methods of commencement. In the case of children whose parents or teachers can give time to them, the frequent use of a magnifying glass for the inspection of the finer markings of flowers or insects, or of the more minute features of their structure, is much to be commended as leading to habits of observation by which the observing faculty itself, as well as the mind which is to be fed by it, will be cultivated and improved. The natural complement to such observation will be the art of drawing, which not only induces the learners to look more carefully at all the objects that they see, but which also affords the best possible tests, by the accuracy and completeness of the representation, of the degree of attention which has been paid to the visual impressions. After reading and writing, indeed, I am very much disposed to believe that drawing, of course including modelling, by reason both of its immediate and of its remote effects upon the senses and the intelligence, is entitled to a very high, even if not to the highest, place among educational agencies. But to pursue this question would carry me far beyond the limits within which these pages must be restrained; and I must be content with the final recommendation that children should be systematically taught and required to use their eyes, not only for the sake of the knowledge to be derived from the practice, but also in order that the eyes themselves may be brought to the highest state of efficiency, and so

may be prepared to render the best possible service to their owners in their passage through the world. The eyes are the chief inlets of knowledge; and the more completely and the more accurately they see, the more and better is the mind likely to understand.

PART II.

HEARING.

CHAPTER I.

1. SOUND; 2. IMPORTANCE OF GOOD HEARING; 3. PREVALENCE OF EAR DISEASE IN CHILDHOOD.

1. *Sound* is produced by the vibration of a body being communicated to the hearing apparatus by means of waves passing through the air.

That the vibrations or tremors of a body produce sound may be demonstrated by sharply striking a glass jar, and thus setting the particles of which it is composed in motion or vibration; a sound is heard, and if the finger be lightly applied to the edge the vibration can be felt, while, if firm pressure be used, the vibration and the sound cease together.

The vibrations of the jar are communicated to the surrounding particles of air, which knock up against the particles farther away, and so by the continuation of the process produce a shock or wave, which at last reaches the drum of the ear, each particle after the shock has passed returning immediately to its original position. If the air were not present there would be no sound. For instance, if a bell be struck in a tightly closed glass chamber from which all air has been extracted by means of an air pump, no sound is heard, but it becomes perceptible as soon as air is allowed to enter. Solid bodies, fluids, and gases, which are composed of particles capable of vibrating, also conduct sound.

The sound waves travel through the air at the rate of about 1090·6 feet each second (Stone). That sound takes some time to travel must be obvious to all who have heard and seen a gun fired at some distance away, when the flash is seen before the report is heard. Broadly speaking, the waves travel faster in liquids than in air, and faster still in solids. An approaching horseman, for instance, can be earlier detected by a trained ear applied to the ground than if the listener were standing. Professor Tyndall demonstrated the same fact in the following way: he chose one of the longest horizontal fence-bars in Hyde Park; an assistant struck the bar at a considerable distance from the point at which the professor's ear was held close to it, when *two* sounds were heard in succession, the first being transmitted through the iron and the second through the air.

In dense conditions of the atmosphere, due to fog or moisture, sound is better conducted; while on high mountains, where the air is rarefied, there is distinct loss of intensity. Wind interferes greatly with the progress of the waves, a fact which every one must have appreciated. Sound waves are reflected from one surface to another, and may in this way be carried with little loss of intensity for considerable distances over level ground, ice, water, or through pipes. This fact is made use of in the construction of ordinary speaking tubes and ear trumpets. Echoes are also produced by the throwing back or reflection of sound waves.

Sounds generally have three different qualities:—

(1) Loudness, depending on the violence of the vibrations.

(2) Pitch, that is they are high, low, flat, etc., depending on the rapidity of the vibrations, the high notes being produced by many vibrations a second, the low ones by few.

The human ear is capable of appreciating, as a continuous musical sound, 30 vibrations a second in the lower scale and 35,000 a second in the higher. The number depends greatly on individual ears, many cannot detect more than 30,000 a second. There is evidence to show that the number appreciated by animals does not correspond to this; for instance, a cat will be disturbed by a high note produced by more than 35,000 vibrations a second and, therefore, inaudible to man.

(3) Quality or acoustic colour, depending on the individuality of the vibrating body. For instance, voices, though not differing in pitch and loudness, can be distinguished one from the other.

Sounds may be classified as either musical or noisy. Musical sounds are produced by regular periodic vibrations, while noisy sounds are due to irregular ones.

The human voice is produced by the vibrations of two thin parallel bands being set in motion by the air forced from the lungs and passing between them. These bands or vocal cords are moved and stretched by different muscles in order to produce differences in pitch or in the number of vibrations.

The hearing apparatus is designed to collect sound waves and to conduct them to the hearing nerve for transmission to the brain, where they are perceived as sound and acted upon. As a matter of fact the world is really one of complete silence, our ears transforming waves from a vibrating body into what we call sound.

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The simplest form of hearing apparatus is a hearing nerve spread out in a small sac, containing fluid ; the variations and extensions of this being numerous and complicated. The organ is usually situated in the head, but in some instances it is placed in extraordinary situations ; many most interesting specimens, prepared by Professor Stewart, may be seen in the Royal College of Surgeons' Museum.

Among the crustacea, some, like the lobster, have the hearing sac in the antennules, some have a hearing drum in their forelegs, others in the abdomen. The hearing organ in man will be described presently.

2. *The importance of normal hearing* cannot be over-estimated. In infancy, hearing is one of the greatest factors in learning to speak. If a child be born deaf it will not speak, although the organs of voice are normal, simply because it is unable to imitate the voices and speech of others. It is only by teaching lip reading that speech will be acquired; even then the voice is monotonous and without inflection, because the child is unable to hear either its own or its teacher's voice.

Sometimes speech is delayed or absent on account of deafness which can be cured, and when the cause is removed speech is at once established.

If a young child has learnt to speak and complete deafness supervenes, the faculty of speech will also be lost, temporarily if a cure of the deafness can be effected ; or permanently, necessitating lip-reading lessons, if it cannot. Apart from extreme deafness, partial loss of function severely handicaps a child. It is prevented, to a great extent, from associating with other children in their pleasures, and the hindrance to education may

be felt all through life. It cannot be insisted on too strongly that many forms of ear disease have their origin in childhood, at which period of life treatment can be applied with the best results. If these diseases be allowed to continue they become less and less amenable to treatment. Besides the loss of hearing, some ear diseases are dangerous to health and even to life.

Many a boy is prevented by deafness from entering a chosen and desirable profession. The Navy, Army, Medicine, the Church, the Law, etc., are all closed against him; even with partial loss of hearing he will be unfitted for taking a high place, and his disadvantages will be felt at every turn. It is exceptional for a deaf man to attain to a high standing in any profession.

The disadvantages to a woman are often equally felt; her chances of marrying are remote, and if she has to get her living, the condition is often a distressing one. Deaf people become unhappy and introspective, they evoke no pity, such as the blind naturally do, simply because they are not so objectively helpless; they are naturally shunned, and looked on as a bore in society. Occupations and amusements are always made easy for the blind, and numerous associations are ready to help them. The deaf are comparatively neglected, though certainly the stone-deaf pauper is educated and put to a trade, but the deaf or partially deaf classes above that have to enter the battle of life on the same footing as the healthy and with very little to assist them.

Nothing can be more pitiable than a deaf or partially deaf woman of the middle classes who has to earn her living, her chances are so restricted. The Charity Organisation Society has under its considera-

tion the obtaining of employment for the deaf and partially deaf who have to earn their own living, and it is to be hoped that something may be done.

3. *In order to show how prevalent deafness and ear diseases are in children* of the lower classes, several examinations have been made in this country and abroad.

The following is a table published by Dr. Barr of Glasgow ("The Hearing of School Children," *Schoolmaster*, 7th September, 1889) :—

Surgeon.	Place.	Children examined.	Found defective.
Sexton	New York	570	74, or 13 per cent.
Weil	Stuttgart	4,500	1,501, or 33·37 per cent.
Moore	Bordeaux	1,768	300, or 17 per cent.
Bezold	Munich	1,885	414, or 22 per cent.
Barr	Glasgow	600	166, or 27·66 per cent.

At a meeting of the Otological Society of the United Kingdom held on 14th April, 1902, a report on the examination of 1,000 children, between the ages three and sixteen, in the Hanwell District Schools, was presented by myself. These children came from the pauper class in the Southwark and City of London Districts. Of these the hearing was more or less deficient in 520; in 88, discharge from the middle ear was present on one or both sides. Many of these children could be permanently cured, but if left untreated will grow up more or less deaf, while the lives of some are in danger. In the discussion which took place, Mr. George Murray gave the result of an examination made by him in 400 children between the ages of six and fourteen; 43 were deaf. Dr. Permewan of Liverpool had examined 203 children between the ages of ten and fifteen years in an

Industrial School in Liverpool. He dealt with the subject from the point of view of the relation between defects of hearing and mental deficiency. According to the report of their teachers, concerning their intellectual sense, he divided the 203 into three classes : *good*, *fair*, and *bad*. The test was made with a watch which could be normally heard at 60 inches.

The result was as follows: of 89 called *good*, the average mean hearing distance was 51 inches; of 52 called *fair*, the average mean hearing distance was 47 inches; while of 62 called *bad*, the average mean hearing distance was 31¼ inches—only half of the normal.

The relationship between low intellectual power and deafness was most marked.

Again, Dr. Thomas Barr of Glasgow in his report, referred to above, deals with the same aspect of the subject: he found that in 140 there were "*twice as many with defective hearing among the backward children as among the forward children*".

A point of much importance is that, in many children, the deafness is slight and only commencing, so slight indeed that the teachers do not notice it, a skilled examination being necessary for its detection. Yet the deafness will, if left untreated, grow worse.

In some countries, Germany, Switzerland and Sweden, for example, the importance of the subject has been realised, and steps taken to ensure proper treatment by the regular skilled examination of the school children. Some such method is necessary in Great Britain, not only as regards deafness and ear diseases, but as regards all diseases, especially communicable ones, such as con-

sumption, those of the eye and skin, scarlet fever, measles, diphtheria, small-pox, etc.

Children are compelled by law to congregate together for purposes of education, and surely it is a logical deduction that every effort should be made to ensure that they are in the best possible condition to profit by their attendance, and that in so doing they run no preventable risk.

In the *Lancet* for 8th November, 1902, will be found the abstract of a report of the daily inspection of the school children of New York.

The daily average attendance was 204,262. The number excluded from attendance and the ailments from which they suffered were as follows: measles, 6; diphtheria, 9; scarlet fever, 18; whooping-cough, 50; mumps, 28; chicken-pox, 22; contagious eye diseases, 3,390; pediculosis (itch), 7,679; contagious skin diseases, 263; acute catarrhal condition of the eyes, nose and throat, 36; miscellaneous, 282; during the first week about 4,700 were excluded!

The children, apparently, were not examined for deafness and ear diseases; apart from that, however, many of the causes of exclusion are fertile sources of ear diseases.

The figures clearly demonstrate what nurseries of disease public schools may be, and how necessary it is that all schools should be medically controlled.

As many diseases of the ear and nose which cause deficiency or loss of hearing, impaired physical and intellectual vigour, and even loss of life, have their origin in infancy and childhood, it is important that they should be recognised, in order that treatment may be applied

at a time when it offers the best chance of permanent cure. Although parents are just beginning to realise this, there is even now considerable ignorance on the subject.

For instance, the ordinary *ear-ache* in childhood, while it is often put down to teething and thought to be of no importance, is in reality not only a menace to hearing but even to life itself.

Again, *a chronic discharge from the ear* is frequently treated with scant attention, the idea being that the child will outgrow it, yet the truth is that so long as discharge is present, untreated, a serious or fatal result may occur at any moment.

The object of these lines is to place before parents, in as clear and simple a manner as possible, the anatomy, physiology and diseases of the ear, the nose and throat, in order that they may recognise disease when it occurs and take measures for its cure.

Treatment will not be dealt with, as it should be invariably left to the surgeon. Household surgery is always risky, unless it is guided by the surgeon's hand, and probably is most dangerous in diseases of the eye and ear.

CHAPTER II.

MECHANISM OF HEARING.

The great function of the hearing apparatus is to collect sound waves and conduct them to the brain, where they are converted into what is called sound.

In each ear there is :—

I. A portion for the *collecting and conducting* of these waves, and

II. An inner or *perceptive* portion where these waves are converted into sound. These two portions will now be simply described.

I. Collecting and Conducting Portion.

This portion consists of: *a* the auricle; *b* 1 and *b* 2 the passage; *c* the drum, and *d* the middle ear.

(*a*) *The Auricle.*—This is the structure which is commonly known as the ear. It consists of a piece of folded elastic gristle covered by skin, where it is attached to the head this gristle is folded round to form the outer opening of the passage.

(*b*) *The Passage* begins at the outer opening and runs practically straight in, ending at the drum which stretches across and completely closes it.

The outer portion, *b* 1, of the passage is formed by the gristle of the auricle folded round; the inner,

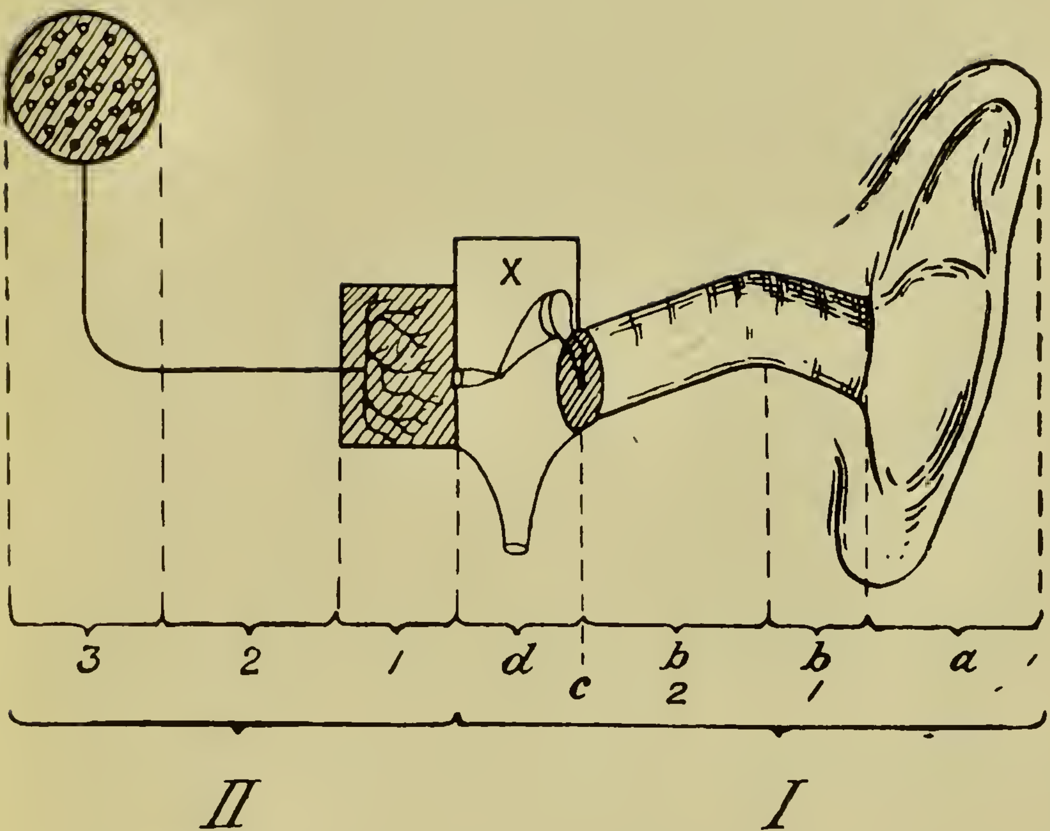

DIAGRAM OF THE HEARING APPARATUS SEEN FROM IN FRONT.

I. Collecting and conducting portion.
II. Perceptive portion.

a. Auricle.
b_1. Outer portion of the passage made of gristle.
b_2. Inner portion of the passage made of bone.
c. The drum with a portion of the outermost hearing bone buried in it.
d. The middle ear with the three little hearing bones running across it, the innermost one fitting into the hole in the inner wall. At x the middle ear is continued backwards. Below, the middle ear is continued as a tube which opens into the space at the back of the nose.

1. The internal ear containing fluid in which the delicate ends of the hearing nerve float. The outer wall forms also the inner wall of the middle ear and has the hole in it.
2. The hearing nerve leaving the internal ear.
3. The hearing centre in the brain receiving the hearing nerve.

b 2, by bone; both are lined by skin which becomes very delicate in the inner or bony portion, from which it is continued completely over the drum, forming its outer coat. The depth and direction vary at different periods of life; at birth there is no inner or bony portion, the outer or gristly part only existing, thus placing the delicate drum very close to the opening. As the child grows, so does the inner or bony portion, so that the drum, as age advances, becomes gradually situated farther away from the outer opening. It has been said above, that the passage runs practically straight in, but slight curves are present which necessitate the pulling of the auricle downwards in early infancy, in order to straighten it; later in life, backwards; in adult life, upwards and backwards.

The outer or gristly part has very fine hairs growing from the surface all round; there are also in the skin numerous glands which secrete the wax ; both the hairs and the wax, together with the curves of the passage, serve to protect the deeper parts, and to prevent the introduction of small particles of dust, etc.

(*c*) *The Drum* stretches right across the bottom of the passage, shutting it off from a cavity called the middle ear.

The drum is of extreme thinness and is composed of three layers; a middle one of strong fibres, an outer one, as we have seen, of skin continued from the bony passage, and an inner of thin mucous membrane which also lines the middle ear.

Running half-way down from the top and embedded in the middle layer of the drum, is a portion of one of the small hearing bones contained in the middle ear.

Sound waves are therefore collected and conducted by the ear and passage to the drum. After reaching the drum they are conducted across a deeper cavity by three little hearing bones ; this deeper cavity is known as the middle ear.

(*d*) *The Middle Ear.*—This is a cavity situated deep in the side of the skull, shut off from the passage, as we have seen, by the drum, and having an inner wall formed of hard bone, in which is a small hole. Across the cavity are placed three little hearing bones. An outer one attached to the drum, an inner one, shaped like a stirrup, the foot plate of which fits into the hole in the inner bony wall, and a middle one which connects the two together.

These bones conduct the waves of sound from the drum to the internal ear.

The top or roof of this middle ear is composed of thin bone, and is usually incomplete in infancy and childhood. On this roof rests part of the brain.

The middle ear, at its back and upper part above and behind the three hearing bones, is continued backwards into another cavity, the outer wall of which is formed of bone and is situated immediately behind the upper attachment of the auricle, where it can be felt.

The roof of this accessory cavity is a continuation of the roof of the middle ear, and therefore has brain lying upon it ; the back wall of this cavity is also formed of thin bone, and has lying against it another portion of the brain, together with a large vein which conveys the blood from the inside of the head to the neck. This cavity is also in communication with a series of spaces or cells situated in the mass of bone immediately behind

and below the auricle. Behind these spaces there also lie a portion of the brain and the large vein.

The lower as well as the front part of the middle ear is continued as a tube running downwards and inwards to open into the space at the back of the nose. The delicate mucous membrane which lines the nose and the space at the back of it is continued up this tube, spreads over the whole of the walls of the middle ear and the cavity behind it, and forms folds round the three little hearing bones.

For the purpose of proper hearing it is necessary that some air should be present in the middle ear, and it is by this tube, which runs from the space at the back of the nose, that air is introduced. It can be readily understood then that, if the tube be blocked from any cause, deafness will result; and that inflammation affecting the mucous membrane of the space at the back of the nose can be easily conveyed by means of the tube, not only to the middle ear, causing perforation of the drum, but to the spaces at the back of the ear. The inflammation may also spread from the middle ear and the spaces to the brain in two situations, to the big blood-vessel, or it may extend inwards affecting the inner portion.

The conducting portion ends at the hole in the inner bony middle ear wall, the hole leading into the inner or perceptive portion.

II. The Perceptive Portion.

This consists of three parts: (1) A bony box, containing fluid in which the hearing nerve ends in extremely

delicate filaments ; (2) the hearing nerve, which passes from this bony box to (3) the hearing centre in the brain.

The inner middle ear wall perforated by the hole into which fits the innermost hearing bone, also forms the outer wall of the internal ear box, so that sound waves are transferred from the innermost hearing bone of the middle ear to the fluid of the internal ear, in which float the delicate terminations of the hearing nerve ; they are then transferred by the nerve to the hearing centre in the brain, where they are perceived and acted upon.

Besides the function of hearing, this internal ear box controls our steadiness or equilibrium, and that is why giddiness is often associated with deafness and ear-syringing.

Test of Hearing in Children.—A child should be able to hear with perfect ease a low whisper at eighteen feet (six long paces) with either ear. In order to test the hearing, simple questions, which a child can easily understand and answer, should be asked, first with one ear stopped up with the finger and the open one turned to the observer and then *vice versa.* Testing with a watch is no guide in childhood ; first, because the tick of every watch varies in intensity, and, secondly, because a child's answers to the test cannot be trusted. It would be an excellent thing if every child were tested in this manner as soon as it is able to understand and answer simple questions, in order that treatment may be at once applied if deafness be found. Teachers should notice whether the backward children are deaf or not. Prompt treatment may make a dull child intelligent, and so alter its whole life's work.

CHAPTER III.

ANATOMY OF THE BREATHING PATHWAY.

We have seen that the middle ear is connected with a space at the back of the nose by means of a tube. The importance then of a healthy nose and throat, with free breathing through the nose, is perfectly clear, and, before proceeding further, the nose, the space behind the nose, and the throat must be briefly described.

The Nose is essentially the organ of respiration, in which are placed the proper mechanisms for heating, moistening, and filtering the air which passes to the lungs ; it also contains the nerve of smell, and the tear ducts from the eyes open into it. Various large spaces in the skull open into it, forming, with the cavity of the nose itself, resonating chambers for the voice.

The nose is divided into two identically shaped cavities by a middle partition or septum which runs straight backwards from the column of skin partition separating one nostril from the other, and ends as a free vertical border running upwards from the back border of the hard part of the roof of the mouth to the roof of the nose.

If the tongue be placed immediately behind the front teeth and be drawn firmly backwards along the centre of the roof of the mouth, it will be found that the front part is hard, forming the hard palate, being

made of bone, while the back part is soft, forming what is known as the soft palate ; it is in the centre at the level of the point of junction of the hard and soft palates that this vertical partition or septum ends.

As each side of the nose is identically the same, *one side only needs description.* Each side consists of a floor, a roof, an outer wall, an inner wall, and front and back openings.

(*a*) *The Floor.*—The floor is formed by the upper surface of the hard part of the roof of the mouth (hard palate) and therefore runs straight backwards.

(*b*) *The Roof* begins at the top of the nostril and runs first upwards to the level of the eyebrows, then straight backwards, where it is very thin, with a portion of the front part of the brain resting upon it, and having minute holes in it for the passage of the branches of the nerve of smell.

(*c*) *The Outer Wall* is irregular in outline, the irregularity being due to the presence of three bodies composed of bone, blood-vessels, and blood spaces covered by mucous membrane. These bodies run horizontally backwards, one above the other, with a dip between each to the back ; all of them ending at the level of the back free border of the septum.

(*d*) *The Inner Wall* is formed by the smooth middle partition or septum, the front part being made of gristle, and the back of bone. It is attached throughout its length below to the hard palate, and above to the centre of the roof of the nose.

(*e*) *The Front Opening* is the nostril, which is lined with skin, and protected by numerous fine hairs from the intrusion of foreign particles.

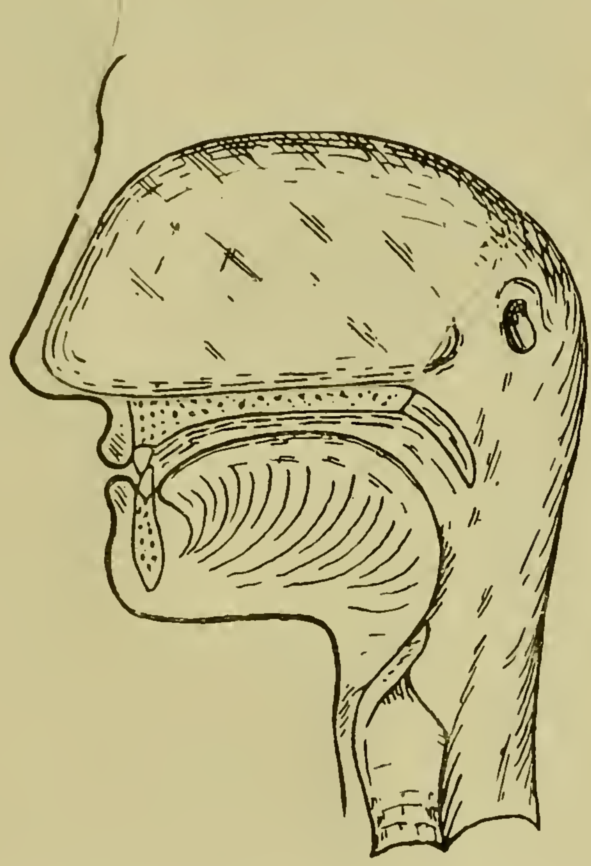

DIAGRAM OF THE NOSE, MOUTH AND THROAT, SEEN FROM THE SIDE.

1. *With the flap down.*—The face is seen in outline. The tongue is present in the floor of the mouth. The roof of the mouth is formed in front by the hard palate and behind by the soft palate. The flap represents the middle partition or septum which divides the nose into two identically shaped cavities and therefore forms the inner wall of each. A space must be imagined between the flap and the outer wall of the nose; it will then be appreciated that the back border of the septum is free, and that front and back openings exist.
2. *With the flap removed.*—The outer wall of the nose is then exposed and shows, in a diagrammatic way, the three blood-containing bodies running one above the other from before backwards. Behind the back ends of these bodies and the septum and above the soft palate is *the space at the back of the nose;* the opening of the middle ear tube can be seen on its side wall. It is on the curved roof of the space at the back of the nose that adenoids grow. Immediately behind and below the tongue is the flap of the voice box which is continued as the windpipe or breathing tube. Behind the voice box is the swallowing tube.

(*f*) *The Back Opening* communicates with the space at the back of the nose; it is roughly oval in shape, and has on its outer side the back ends of the three blood-containing bodies, the inner wall being formed of the back free border of the septum.

The whole of the nose is lined by a delicate pink moist membrane (mucous membrane), which has a very large blood supply, and contains numerous glands secreting mucus.

Various air spaces open into the nose, the chief being the one above each eye, opening into the roof, and another behind the cheek in the upper jaw above the teeth, opening into the outer wall of the nose about its middle, and between two of the blood-containing bodies which run across it. These spaces are lined by mucous membrane continuous with that lining the nose.

The Space behind the Nose.—This lies behind the nose and above the soft palate; and is bounded in front by the two back openings of the nose with the middle partition intersecting them. Its roof is formed by a continuation of the roof of the nose, sloping downward at first but becoming straight lower down where it forms the back wall of the throat.

On each side of the space, and immediately behind the back ends of the blood-containing bodies, is situated the opening of the middle ear tube. The space opens below into the back of the throat, behind the movable soft palate and the uvula. The whole is lined with a continuation of the mucous membrane in the nose; and, as we have seen before, this lining membrane is also continued up, through the middle ear tube to the middle ear itself.

A tonsil, stretching from one side to the other, is normally situated on the mucous membrane on the curved roof of the space, immediately behind the free border of the septum. If this becomes enlarged it forms what are known as "adenoids".

The close proximity of these adenoids to the openings of the middle ear tubes can be readily appreciated.

The Throat.—If the throat, with the tongue pushed down, be looked at in a mirror, it will be seen that the soft palate is movable and that it ends as a free border with the uvula in the centre. On each side the soft palate will be seen to divide into two folds, which run downwards and enclose the tonsils. Behind the soft palate and uvula is the opening of the space at the back of the nose into the throat. The back wall of the throat is the continuation downwards of the roof of the nose and of the space at the back of the nose.

If the tongue be well pushed down, a small flap which forms the lid to the voice box or larynx can occasionally be seen immediately at the back of it. The configuration of the voice box can be felt in the front of the neck. Behind the voice box, the walls of the back of the throat join to form the food tube.

The air, when breathed in, passes through both nasal cavities, where it is warmed by its contact with the blood-containing bodies, moistened by the mucus secreted by the glands in the mucous membrane, and filtered, first by the fine hairs which line the front openings, and then by the mucus, which is antagonistic to the growth of microbes ; it then passes through the space at the back of the nose over the openings of the middle ear tubes, then behind the soft palate, and

through the throat to the voice box, and so to the windpipe and lungs.

The openings of the middle ear tubes in the space at the back of the nose are usually closed, but open during swallowing. A click can be heard in the ears each time swallowing occurs. Food, after being masticated, passes by the act of swallowing over the top of the voice box, the lid of which is then shut, to reach the food tube. If anything accidentally enters the voice box, choking and coughing are set up ; this little accident is commonly known as " swallowing the wrong way ".

CHAPTER IV.

THE CARE OF THE EARS IN CHILDHOOD.

THIS may be considered from two points of view :—

1. *As regards the ear itself*, and

2. *As regards the general health and hygienic surroundings.*

1. *As Regards the Ear.*—It is unnecessary in washing a child to clean more of the ear than can be reached by means of a soft towel covering the little finger. It is unnecessary, and may be harmful, for water or soap to enter more deeply. It is a common practice among nurses to screw the edge of a towel up into a point and introduce it into the passage, but this should never be done.

In any disease of the ear causing pain or deafness, it is a common practice to introduce various substances, such as warm oil, or even to syringe with soap and water, and it used to be quite usual for pieces of hot onion or plugs of tobacco to be so used. It should be a strict rule that nothing whatever under any circumstances should be introduced into the passage without a doctor's orders. A child's ear should never be boxed, for a blow on the ear by compressing the air in the passage may either rupture the drum, with serious or even fatal results, or it may concuss the nerve in the internal ear box, leading to temporary, or even some-

times more or less permanent, deficiency of hearing. Any teacher who boxes a child's ears should be prosecuted as a deterrent to others.

With regard to bathing in the river, sea, or swimming bath, it should never be allowed when there is a discharge from the ear, or when a discharge has ceased but has left a perforation in the drum. Of the existence of the latter the surgeon alone is able to decide. Very grave and even fatal results have occurred from the introduction of water into the middle ear under these circumstances. The water so introduced, besides being cold, contains microbes which may increase or cause inflammation in the middle ear, and this in its turn may induce serious bone disease or inflammation of the brain.

Whenever syringing is ordered by a surgeon the water used for the purpose should always be previously boiled, and allowed to cool to a temperature which feels pleasantly warm to the finger. Any syringe used for the ear must be used for that alone, and should be kept in a trustworthy antiseptic solution.

If a foreign body be placed in the ear, *no effort whatever should be made to remove it until a surgeon has seen it.*

2. *As Regards the General Health and Hygienic Surroundings.*—In order to prevent disease of the ear and of the breathing pathway, or, indeed, any disease, a child's general health and surroundings demand the utmost care in order that it may be strong enough to resist the invasion of micro-organisms, or to wage successful battle in the event of their obtaining a foothold.

The general care of infants and children will be found excellently described in Chavasse's book, *Advice*

to a Mother, edited by Dr. George Carpenter, and every mother should possess a copy.

To give an infant the best chance of life it cannot be too strongly insisted on that the mother should nurse it herself, unless a contrary order is given by the doctor. It is, at the least, unfair to bring a child into the world and not to give it this natural start in life. To omit this duty is bad both for the child and the mother.

Besides the feeding, fresh air and sunlight are equally important. Nurseries should be as large and well lit by windows as possible. A separate one should be had for sleeping. Each child requires *at least* eight feet of space in every direction, especially in the night nursery. An infant or child should never sleep in the same bed with the mother or nurse, and if there are several children in the same room, each should have its own cot or bed, placed out of any draught. Gas is unhealthy, and nurseries should be lit with electric light if possible, or by candles or oil lamps. Sleeping suits are preferable to night-gowns, as children are frequently in the habit of kicking off the bed-clothes. The windows of nurseries must never be closed, especially at the top. Chimneys should never be blocked; nurses frequently pull the register down in cold weather, thus abolishing a most important means of ventilation. The temperature of the nurseries should be kept at about 60° Fahr.

The floors should be either of polished wood, or covered with parquet or linoleum, with movable small pieces of carpet, having as little nap as possible, for the child to lie or roll on. Carpets are difficult to keep clean, and they harbour microbes.

Children should be out in the fresh air and sunlight as much as possible, and they should go out, properly clad, in almost all weather, except fog and much rain. Infants should be carried in the mother's or nurse's arms, in order that warmth may be communicated. Colds occur by infection from one person to another; and by any cause, such as draughts and wet feet, which diminishes the resisting power of the system and allows micro-organisms to cause inflammation of the breathing pathway. Care should be taken that nurses are free from disease, especially consumption.

Infants seem to require something in their mouths to chew or suck; it is a good thing to encourage this, as it exercises the muscles of their jaws and assists in the proper development of the parts.

The ventilation of the class-rooms in our schools is often faulty, and the dormitories are frequently over-crowded. Parents should investigate these points themselves before sending their children to any school.

CHAPTER V.

DISEASES OF THE EAR.

The most frequent causes of deafness and ear diseases in childhood will now be considered in the same order in which the anatomy was described, namely :—

1. *Diseases of the external ear*, that is of the auricle and passage.

2. *Diseases of the middle ear.*

3. *Diseases of the internal ear*, that is of the internal ear box, the hearing nerve, and the brain.

1. The External Ear.

(1) *Birth Defects.*—Occasionally the auricle may be deformed with complete absence of a passage, or the auricle may be well formed whilst the passage may be closed. These deformities of the outer ear are usually associated with some deformity of the perceptive portions, causing complete and incurable deafness on the side affected. One side alone is usually so deformed.

(2) *Foreign Bodies in the Ear.*—Children not infrequently put various articles in their ears or have them put in there by other children. A foreign body so introduced is not as a rule put far in. Its presence in the ear is not of so much danger as are ignorant and rough attempts at removal. No one but a surgeon should on any account attempt removal; it is a common

thing for ignorant people, in their endeavours to remove a foreign body, to push it farther in; sometimes perforating the drum, and causing inflammation of the middle ear, which has not infrequently led to permanent loss of hearing and even death. *Under no circumstances should attempts be made to remove a foreign body, unless a skilled examination has been made to make certain that it is present,* for sometimes the foreign body either was never present or has fallen out; and it has happened that attempts to remove a foreign body that was not present, nor ever had been, have resulted in grave injury and death.

(3) *A Collection of Wax.*—The normal secretion of this material is sometimes excessive, and then, owing to the curves of the passage, it is unable to dry and escape, but collects in the deep passage until this is quite obstructed, and the sound waves are thus prevented from reaching the drum. This condition is often present on both sides, and is evidenced at first, before complete blocking has occurred, by periods of deafness apart from a cold, alternating with perfect hearing, and becoming worse after a bath, when the water causes the mass to swell up. Marked continuous deafness occurs when the passage becomes completely blocked.

A moist brown material may sometimes be seen in the aperture, or it may mark the towel on washing. There is no pain or tenderness connected with these collections, which tend to recur all through life.

(4) *Boils.*—These are always situated in the gristly portion of the passage, and are due to a small and localised inflammation set up by a microbe. Sometimes the poison is conveyed by the child picking a boil in

other parts of the body and then conveying the poison on its finger to the ear; sometimes it is caused by a discharge coming from the middle ear. The boils begin with extreme tenderness just inside the passage, the slightest movement of the auricle causing intense pain. The child will not lie on the affected side, and cries on the slightest pressure being made, or when the jaw is moved. A red swelling can be seen almost blocking the passage. This red swelling comes to a head and bursts, the discharge being stained with blood; the child all this time may be acutely ill, screaming with pain, refusing its food, unable to sleep, and having a high temperature. After the bursting all these symptoms rapidly disappear, and the part heals, but, unless care is taken to purify the parts and improve the general health, there is always a tendency for fresh boils to form.

(5) *Eczema.*—Eczema is often seen on the auricle in the outer passage associated with eczema elsewhere, the head especially, or it may be due to a discharge from the middle ear. It is evidenced by a general swelling and rawness of the parts, with a watery discharge from the surface which dries into crusts. The affected parts itch a great deal, and are somewhat tender. The child continually scratches the surface with its finger, and by that means may carry poison to other parts, occasionally to the eye. Sometimes the watery discharge and the crusts collect in the passage, becoming extremely offensive and causing deafness. The child gets irritable and cries a great deal from want of sleep owing to the itching.

There is another form of eczema due to attempts to

clean the ear with towels, hairpins, etc.; the irritation so produced causes swelling, which may almost block the passage, as well as tenderness and watery discharge, the latter sometimes collecting in the passage and becoming extremely offensive.

2. The Middle Ear.

The diseases of the middle ear may be classed into two divisions:—

(*a*) Those causing discharge from the passage.

(*b*) Those without discharge.

In both varieties the presence of adenoids in the space at the back of the nose is the great exciting cause. These adenoids will be described later on, when the causes of nasal obstruction are considered.

(a) Those with a Discharge.—These may be either, (1) acute, or (2) chronic.

(1) *Acute.*—"Ordinary earache." Acute discharge from the ear results from an acute inflammation of the middle ear. The inflammation spreads from the space at the back of the nose up the middle ear tube, and, therefore, anything which causes inflammation of the nose or throat may cause this acute inflammation of the middle ear. The most common causes are a common cold, influenza, and all diseases which cause inflammation of the throat, such as scarlet fever, measles, diphtheria; it must, however, always be borne in mind that adenoids are a great predisposing cause.

Very rarely the middle ear may become inflamed by extension from the passage. This may arise from injury, such as an ignorant attempt to remove a foreign

body from the passage, or an inflammation, such as erysipelas, may spread from the head down the passage.

During the course of a cold or of any of the illnesses we have mentioned, the child may be suddenly seized with very severe pain in the ear, extending up the side of the head, with a high temperature, loss of appetite, loss of sleep, screaming fits, even deliriousness or unconsciousness. In early infancy it is sometimes difficult to clearly make out from what the child is suffering; the hand may be put up to the ear, or the child may roll its head about on the pillow, screaming when moved or disturbed, and often the real trouble is not recognised until the blood-stained discharge bursts through the drum, and escapes from the ear. As soon as the discharge has occurred, the child is at once immensely relieved, and if the disease takes a favourable course no further pain is complained of, and the discharge soon ceases. If adenoids are present, the child has frequent attacks of this kind.

The attack may not follow this safe course, and if the anatomy of the middle ear and of the space behind the ear be remembered, it can be readily understood that any attack of this nature may cause: (1) an abscess to form behind the ear, the matter having perforated through the bone; (2) inflammation of the coverings of the brain, or what is known as meningitis; (3) an abscess to form in the brain in either of the situations which lie in contact with the middle ear and its spaces; (4) general poisoning by invading the big blood-vessel which lies behind the spaces.

It must be thoroughly recognised that no one can tell when this so-called ordinary earache in children is

going to cause one or other of these dangerous or fatal illnesses.

The later results that may follow are: considerable and permanent deterioration of hearing due to destruction of the middle ear structures; a permanent perforation through the drum; or bone disease of the middle ear walls, resulting in the ordinary chronic discharge from the ear.

(2) *Chronic.*—The chronic discharge is due to: (1) neglect of the acute attack; (2) bone disease left by the damage done either by an acute attack or series of attacks; (3) an unhealthy condition of the nose or space at the back of the nose; (4) tuberculosis or consumption. The discharge may be very profuse and offensive, and cause, by its poisonous nature, as we have seen, eczema or boils in the passage. Polypi may form, and are usually indicated by occasional attacks of bleeding from the ear, or by blood-stained discharge. These polypi are evidences of either neglect or of bone disease. This chronic discharge is likely to cause any of the grave troubles mentioned as a possible result of an acute discharge. *A child with a chronic running from its ear is in peril of its life from hour to hour*, besides the serious and more or less permanent diminution of hearing which invariably accompanies the condition.

Tuberculosis or Consumption.—A child with consumption of the lungs sometimes has the middle ear affected by extension of the micro-organism of consumption (tubercle bacillus) up the middle ear tube. The disease shows itself by a discharge from the ear beginning *without pain* after a period of discomfort and deafness. The condition is an exceedingly grave one.

It is a popular fallacy, which dies very hard, that it is dangerous to stop a chronic discharge from the ear. It is based on the fact that, immediately before any grave consequence results, the discharge often ceases abruptly. The fallacy is perfectly obvious, for if the cause of the discharge be removed by the surgeon, the risk of serious or fatal consequence is at once abolished.

(b) Those without Discharge.—These may also be either acute or chronic. Here again adenoids are the main cause; by their presence they not only obstruct proper nose breathing, cause constant colds, and prevent the proper opening of the tube, but they also keep up a constant catarrhal condition of the delicate lining membrane of the space at the back of the nose and the tube, and thus prevent the proper introduction of air into the middle ear which is necessary for perfect hearing.

(1) *Acute.*—During a cold, one or both ears may quickly become deaf without pain, but with a feeling of heaviness in the head and noises in the ear. The trouble is due to swelling of the lining membrane of the space at the back of the nose, and of the middle ear tube, preventing the introduction of air into the middle ear. As the cold gets well the hearing returns, often suddenly, on swallowing, as this action opens the mouth of the tube; this, however, does not always occur, and treatment by the surgeon becomes necessary.

Sometimes the cold extends entirely up the tube to the middle ear itself, causing swelling of the lining membrane and outpouring of catarrhal fluid into the spaces; this condition is more difficult to get rid of, and may lead, by rupture of the drum, to discharge from the ear.

(2) *Chronic.*—A child with adenoids will often have frequent attacks of deafness with each cold, and, if these are not properly treated, recovery after every attack becomes less complete, until a chronic condition of more or less deficiency of hearing is produced. Or this chronic deafness, without discharge, may be entirely due to the continual blocking of the tube by adenoids.. In both of these conditions, the hearing, if left untreated, becomes in later life permanently greatly reduced and severely handicaps the subject both professionally and socially. Children suffering from this form of deafness are dull and apparently inattentive ; they are frequently punished at school for the latter, while in reality treatment of the deafness is what is required, and if it be undertaken early a complete cure results.

There is another form of chronic middle ear trouble, without discharge, which sometimes has its commencement early in life. It is due to a gradual change going on in the lining membrane of the middle ear, and is not associated with adenoids or any disease of the nose or throat. It is often hereditary, and for this reason persons afflicted with this form of deafness should think carefully before marrying. Its onset is very gradual and insidious, and it is only after it has been in progress for some years that the deterioration is noticed ; the trouble progresses until great deafness results.

3. The Internal Ear.

Diseases affecting the delicate terminations of the hearing nerve in the internal ear box usually cause very severe and often complete deafness, so that if *both* ears

are affected a child, owing to its not being able to hear and so imitate others, never speaks at all if the trouble occurs in early infancy; or, if it has begun to speak, will quite lose the faculty, in either instance becoming what is known as a deaf mute. The causes of diseases of the internal ear may be divided into (*a*) congenital, and (*b*) acquired.

(a) Congenital.—Congenital internal ear deafness is usually due to some malformation of the perceptive portions of the hearing apparatus, occasionally associated with malformation of the auricle; sometimes it is hereditary. If both ears are affected, as we have seen, the child will not speak at all until it is taught lip reading. The lip-reading lessons should be begun as early as possible, at about five years of age; signs or finger alphabet should never be used; the child will be able to read from people's lips and will speak, but in a monotone, as it is unable to hear its own voice, and therefore cannot give inflection to it.

(b) Acquired.—Here, again, if both ears are affected in infancy, the faculty to speak becomes lost and lip-reading must be taught.

(1) *Injury.*—The most common causes are from injury. A fall on the head or a crush of the head will sometimes, by injuring the perceptive portion in some part of its course, produce complete deafness on one or both sides.

An accident to the head, associated with free bleeding from the passage, is always very dangerous, not only to life, but to hearing. Exposure to a very loud noise (especially if unexpected), or a blow on the ear, causes temporary or even permanent deafness.

(2) *Inflammation.*—An inflammation of the middle ear may invade the internal ear box, especially in scarlet fever and consumption, and so cause permanent loss of hearing on one or both sides. Inflammation of the membranes of the brain is not at all an unusual cause of complete loss of hearing.

(3) *In various general diseases* the internal ear is in danger, such as : mumps, typhoid fever, influenza and general inflammation of the glands. In whooping-cough a blood-vessel may rupture owing to the violence of the cough, and cause effusion of blood into the internal ear box, which will more or less destroy the hearing.

(4) *Inherited Blood Taint.*—In this disease internal ear deafness of a very grave type comes on sometimes gradually, often more or less suddenly, without pain, but sometimes with giddiness, first in one ear and then in the other. A peculiar inflammation of the eyes often precedes the deafness. As the eyes improve, the hearing begins to go. The trouble is most frequently seen between the ages of ten and fifteen years. The hearing, unless treatment is promptly applied, may be absolutely and permanently lost, the child becoming a deaf mute, or very great diminution may result.

(5) *Tumours.*—Tumours may grow in any part and implicate the hearing apparatus ; the ear trouble under these circumstances is, however, of secondary importance.

CHAPTER VI.

DISEASES OF THE BREATHING PATHWAY.

In order to avoid repetition, it may now be stated that various diseases, such as scarlet fever, measles, diphtheria, influenza and typhoid fever may cause inflammation of the breathing pathway, with consequent obstruction and danger to the ears.

1. Nose.

Obstruction of the nose is common to diseases of the nose and the space at the back of the nose. The signs common to all are: *open dry mouth*, with heavy breathing by day; *snoring* by night, with a dry and uncomfortable throat on waking, and *thick muffled speech* with inability to *pronounce M and N clearly*. If obstruction be long continued, further results are seen, and these will be described under the most common cause of prolonged nasal obstruction in infancy and childhood, *viz.*, adenoids.

Any disease of the nose or space at the back of the nose may affect the ears either by the spread of inflammation or by obstruction to proper nose breathing.

(1) *Foreign Bodies in the Nose.*—Various small articles such as peas, beans, buttons, heads of wooden toys, etc., are occasionally introduced. As a rule they are

not placed far in, but may be pushed deeper by efforts made to remove them.

The delicate lining of the nose resents the intrusion of the foreign body, and swells up, causing blocking of the affected side, and pours out a discharge which becomes extremely offensive. *Blocking of one side of the nose in a child, accompanied by offensive mattery discharge, is nearly always due to the presence of a foreign body.*

(2) *Injury.*—A fall or violent blow on the nose may displace or fracture the middle partition, or, if extreme, may push in the bridge of the nose. Under these circumstances bleeding is profuse, with swelling and bruising of the surrounding parts. Blocking of one or both sides is at once produced. Rectification of deformities should *at once* be undertaken, or else the parts firmly heal in the displaced condition, causing permanent obstruction and deformity which may be difficult to deal with.

Irregularity and displacement of the middle partition may result from imperfect development of the nose passage due to prolonged obstruction.

(3) *A Common Cold in the Head.*—This is due to inflammation of the lining membrane of the nose, the space at the back of the nose and throat ; such inflammation being caused by a micro-organism. Anything which depresses the vitality generally, such as a draught, getting wet, or exposure to cold weather without proper protection, or some unhealthy condition of the passages themselves, especially the presence of "adenoids," allows the organism to effect a foothold and to produce the inflammation. Colds are frequently caught by one

person from another; care, then, should always be exercised, when parents or nurses are affected, that a child does not catch it, or that one child does not give it to another. Kissing should be prohibited, and all feeding articles should be marked and used by the affected child only, and should be regularly scalded. If colds are frequent, the fact clearly shows that there is some faulty condition of ventilation, clothing, or breathing pathway.

(4) *Chronic Enlargement of the Blood Containing Bodies of the Outer Wall of the Nose.*—The enlargement of these bodies is due to general ill-health, frequent colds, or the presence of "adenoids". The symptoms are those of a prolonged cold in the nose. Both sides are more or less blocked, or the blocking may alternate. A watery discharge occurs from both nostrils, and may cause soreness of the nostrils and upper lip.

(5) *Eczema of the Nostrils.*—This is caused by an irritating discharge from the nose, or by infection from other parts of the body. The nostrils are raw and red, with a watery discharge, which dries, causing yellow crusts to form. Itching is intense, giving rise to continual rubbing and scratching, which make matters worse. The condition is often present just inside the front openings, producing considerable obstruction by the swelling of the parts, the discharge, and the crusts.

(6) *Inherited Blood Taint.*—Infants with the taint are often quite healthy when born, but after a few weeks they begin to lose flesh and to have a wizened, earthy appearance. At this time the nose is often stopped up by inflammation of the lining membrane, causing "snuffling," with a watery or even thick offensive dis-

charge from both sides of the nose. The inflammation may attack the bones, causing the bridge of the nose to sink in, although such a deformity is more likely to occur, when the taint is present, between the ages of three years and fourteen years.

(7) *Tumours* may grow in the nose itself, or the cavities may be invaded by tumours growing from the space at the back of the nose. Obstruction is at first slight, but later becomes complete, with deformity of the face due to the pressure of the tumour. Nose bleeding is frequent, and the general health is seriously affected.

2. Space at the Back of the Nose.

The space may be implicated in all inflammatory affections which affect the nose and throat, and, as previously stated, tumours may grow from some part of it, but the great cause of prolonged obstruction to the nose, and of deafness and ear diseases in infancy and childhood, is enlargement of the tonsil which lies in the roof of the space, a condition commonly known as " adenoids ".

Adenoids, or Enlargement of the Tonsil at the Back of the Nose.—If the anatomy of the space be remembered, it will easily be understood how enlargement of the tonsil will prevent proper nose breathing, and cause deafness, by preventing the proper opening of the middle ear tube, and by keeping up a chronic catarrh which obstructs it.

Adenoids are often present in very early life, and are indicated by the open mouth of the child, its heavy noisy breathing by day, and snoring by night.

When taking food frequent stops have to be made in order to breathe through the mouth. During the night natural efforts are made to breathe through the nose, but as they are unsuccessful the child gets less and less air, until a point is reached at which it is imperative that more air be taken into the lungs, consequently the child wakes up as if fighting for breath, then takes several deep breaths by the mouth, and goes to sleep again. This cycle of events occurs again and again.

The general health suffers, owing to a deficient supply of oxygen, and disturbed nights. Occasionally attacks of croup occur, night terrors are often present, and wetting the bed is sometimes a sign.

As the air is not properly filtered, infections of all sorts are apt to occur, and bronchitis and frequent colds result. Acute earache, with subsequent chronic discharge, may occur at any moment. An offensive discharge may be constantly running from one or both ears, with all the consequent dangers to health and life. Often deafness is present, and may be so great that the child, being unable to copy others, does not learn to speak.

Treatment at this early stage will effect a complete cure.

If left untreated, the child is stunted in its growth both physically and intellectually. The constant open mouth and deafness cause the child to look, and actually to be, stupid. Education is therefore, *to a very great extent, wasted.*

The upper jaw does not develop properly, but remains small and narrow, so that the upper teeth

become crowded together, and often decay early, with overlapping or projecting of the middle ones.

The roof of the mouth becomes highly arched. The nose is narrow and pinched in behind the nostrils. The voice is thick and muffled, with inability to pronounce M and N distinctly, the "M" becomes "B," and "N" "D". The chest becomes deformed and the shoulders round.

Enlargement of the throat tonsils is a frequent concomitant. Sometimes the more marked of these signs are absent, ear diseases being the chief.

It is quite true that, as a child advances to puberty, adenoids often get less in amount, but they often do not disappear entirely, but remain in a lessened degree well on into life, acting as a constant menace to the ears. This tendency to their diminution must not be relied on, for although the adenoids do get very much less, or even disappear, yet they leave behind permanent ear, nose, and throat disease, and mental and physical deteriorations. To leave them alone when they are causing trouble is like leaving a house on fire to burn itself out: the fire will certainly disappear, but the house is ruined.

The subjects of adenoids in childhood can frequently be recognised all through life. Many have chronic and intractable ear diseases and deafness, others show the resulting deformities of the face and chest, while others are frequently suffering from the effects of chronic mouth breathing.

The condition must be recognised early and treated if the child is to become a healthy, vigorous member of the community. Although a great deal can be done

later in life by treatment, yet some discomfort or signs will persist.

3. Throat.

Chronic enlargement of the tonsils is the most common disease in infancy and childhood. It is often associated with adenoids. The enlarged tonsils give rise to frequent sore throats and difficulty and pain in swallowing. They are often associated with enlarged glands in the neck. An abscess may form during an attack of inflammation in the tonsils, causing a serious and occasionally dangerous condition.

CHAPTER VII.

REQUIREMENTS OF THE PUBLIC SERVICES AND LIFE INSURANCE OFFICES.

THE public services demand practically perfect hearing in both ears. A discharge from one or both will disqualify, as also will marked enlargement of the throat tonsils and the presence of adenoids. In the great majority of life insurance offices, a discharge from the ear will either disqualify or will necessitate a heavy premium being paid.

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